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ADHD Medication on Child Welfare

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ADHD Medication on Child Welfare

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Abstract

This dissertation examines the causal effects of ADHD medication on child welfare, and investigates the effects of a supplemental income program on the diagnoses of learning disabilities.

In 2011, 6.4 million children were diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD) with nearly 70% of them taking ADHD medication. However, little causal evidence exists on the effectiveness of ADHD medication. The first two chapters of this dissertation utilize an instrumental variable strategy to identify the effects of ADHD pharmaceutical treatment on South Carolina Medicaid children's academic, behavioral, and health outcomes. The first chapter estimates the causal effects of ADHD medication on South Carolina Medicaid students' elementary, middle, and high school test scores as well as grade retention. We find mostly adverse effects. If treated with ADHD medication, male and female students are more likely to repeat a grade and females are less likely to pass middle and high school state standardized tests. This negative effect is most apparent for females diagnosed with combined inattentive and hyperactive/impulsive ADHD. In contrast, ADHD medication improves test performance for males diagnosed with inattentive ADHD in elementary school, but these effects vanish by middle school.

The second chapter investigates the effects of ADHD medication on the probability of risky sexual behavior outcomes (STDs and pregnancy), substance abuse disorders, and injuries. Our findings suggest that pharmacological treatment has substantial benefits on behavioral outcomes. It reduces the probability of contracting an STD by 3.6 percentage points (5.8 percentage points if we include STD screening), reduces the probability of having

a substance abuse disorder by 7.3 percentage points, reduces the probability of injuries by 2.3 percentage points per year, and associated with them Medicaid costs decrease by $88.4, or 0.054 of a standard deviation.

The final chapter estimates the impact of an infant's receipt of Social Security Supplemental Security Income (SSI) disability benefits on future educational achievement and learning disability diagnoses. We exploit program eligibility discontinuities in birth weight to obtain plausibly causal estimates of the long-run impacts of disability benefits on childhood educational achievement. Our findings suggest that individuals who are eligible for SSI disability benefits are less likely to repeat a grade in elementary and middle school, but are more likely to have a reported learning disability.

Dedication

For Ryan - thank you for always believing in me, for making my dreams a priority, and pushing me to achieve them.

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Chapter 1

ADHD Medication Effects on Primary and Secondary Students' Academic Achievement (with Anna Chorniy)

1.1 Introduction

Attention-deficit/hyperactivity disorder (ADHD) is one of the most common and fastest growing mental health disorders. By 2012, approximately 11% of children age 4-17 years old were diagnosed with Attention-Deficit/Hyperactivity Disorder (Visser et al. (2014)). Children diagnosed with ADHD are more likely to repeat a grade, be enrolled in special education, and have lower reading and mathematics test scores (Currie and Stabile (2006)). ADHD symptoms of inattentiveness, hyperactivity and impulsivity in the classroom are believed to contribute to this poor performance (Barkley (2006)).

Of the children diagnosed with ADHD, 69% of them take ADHD prescription medications for treatment (Visser et al. (2014)). ADHD medication has been shown to mitigate ADHD symptoms of inattentiveness, hyperactivity and impulsivity (MTA (1999); Swanson et al. (1993)), leading medical experts to believe that medication could improve academic productivity (Barkley (2006)). Yet, ADHD medication is controversial due to the trade-off between easing ADHD symptoms and encountering severe side effects, as well as a lack of evidence on the long-term effects of ADHD medication on a young brain and body. Many children suffer from side effects such as decreased appetite, weight loss, irritability/anger, insomnia, headache, stomachache, and dizziness (Barkley (2006); Cascade et al. (2010)).

Despite the large number of children taking medication for ADHD, little evidence exists on the effects of ADHD medication treatment on academic performance. We utilize a unique data set that allows us to investigate the causal effect of ADHD treatment on academic outcomes in both the short-run, in the form of elementary test scores, middle school test scores and grade retention, and long-run in the form of high school test scores. To address the endogeneity of ADHD treatment receipt, we use physician prescribing behavior as an instrument following Duggan (2005), Dalsgaard et al. (2014), and Chorniy and Kitashima (2015).Previous research indicates that ADHD is manifested differently across gender, and that these distinctions become more prevalent in teen years due to hormonal influences (Hinshaw et al. (2012)). Therefore, we first examine the effects of ADHD medication treatment by gender. Medicaid data allow us to identify the individual's ADHD subtype based on symptoms: predominantly inattentive versus combined inattentive and hyperactive/impulsive symptoms. To our knowledge, our study is the first to consider heterogenous treatment effects by gender and ADHD subtype: 1) females with combined inattentive and hyperactive/impulsive ADHD, 2) females with predominantly inattentive ADHD, 3) males with combined inattentive and hyperactive/impulsive ADHD, and 4) males with predominantly inattentive ADHD (see further discussion in Section 1.2.1).

Our results suggest that ADHD medications have mostly adverse effects. ADHD medication increases the probability of grade repetition for both male and female students and lowers female students' middle school and high school test performance. The negative effect of medication on test performance is particularly driven by the subsample of females diagnosed with combined inattentive and hyperactive/impulsive ADHD and consistent with human capital accumulation theory, the magnitude of the negative effect increases with each subsequent grade. We also find evidence that ADHD medication has positive effects for elementary school males diagnosed with predominantly inattentive ADHD, but these effects vanish by middle school.

1.2 Background and previous research

1.2.1 ADHD Symptoms and Gender Distinctions

The National Institute of Mental Health defines attention-deficit/hyperactivity disorder (ADHD) as a brain disorder in which individuals display an ongoing pattern of inattention, hyperactivity, and/or impulsivity that interferes with functioning and development. Inattentive symptoms include difficulty sustaining attention, difficulty in organizing tasks and activities, and overlooking details resulting in careless mistakes in schoolwork. Children with hyperactive/impulsive symptoms appear to be constantly in motion or act as if they are ”driven by a motor”, squirm in their seats, and run around or climb in inappropriate situations. natbib Males are more likely to be diagnosed with ADHD due to more apparent symptoms (Akinbami et al. (2011)). Relative to males diagnosed with ADHD, females diagnosed with ADHD have lower ratings on hyperactivity, inattention, and impulsivity. On the other hand, females with ADHD had greater intellectual impairments and more internalizing problems than males with ADHD (Gershon and Gershon (2002)). Psychologists stress the importance of considering ADHD gender differences due to females' hormonal influences that can greatly affect their behavior. These gender distinctions become more important as individuals diagnosed with ADHD develop into their teen years. According to Hinshaw et al. (2012), after females start puberty (between ages nine and 11) and after menstruation begins (between ages 11 and 14), their hormones can have profound effects. Females with ADHD in their early teens have more academic problems, more aggressive behavior, and higher rates of depression than females who do not have ADHD. This pattern contrasts with many males, whose overt hyperactivity decreases so significantly after puberty that, for decades, it was thought they outgrew their ADHD (Littman (2012)).

Attention-Deficit/Hyperactivity Disorder is divided into three subtypes based on the displayed symptoms: predominantly inattentive (henceforth PI-ADHD), predominantly hyperactive/impulsive (henceforth PH-ADHD), and combined inattentive and hyperactive/ impulsive (henceforth combined-ADHD), with combined-ADHD being the most prevalent diagnosis (American Psychiatric Association (1994)). The division of ADHD subtypes is important to consider given that differing symptoms may be hindering academic performance through different mechanisms. Children diagnosed with PI-ADHD may perform worse in school due to difficulty staying focused on a task or activity. Children diagnosed with combined-ADHD may perform worse in school because they are unable to control their impulses and hyperactivity causing them to lose focus.

Due to known gender differences of ADHD, our analysis considers treatment effects by gender. As a contribution to the literature, we also consider heterogenous treatment effects based on the individual's subtype of ADHD. We stratify the sample by gender and ADHD type: 1) females with combined-ADHD, 2) females with PI-ADHD, 3) males with combined-ADHD, and 4) males with PI-ADHD.[1]

1.2.2 ADHD and Education

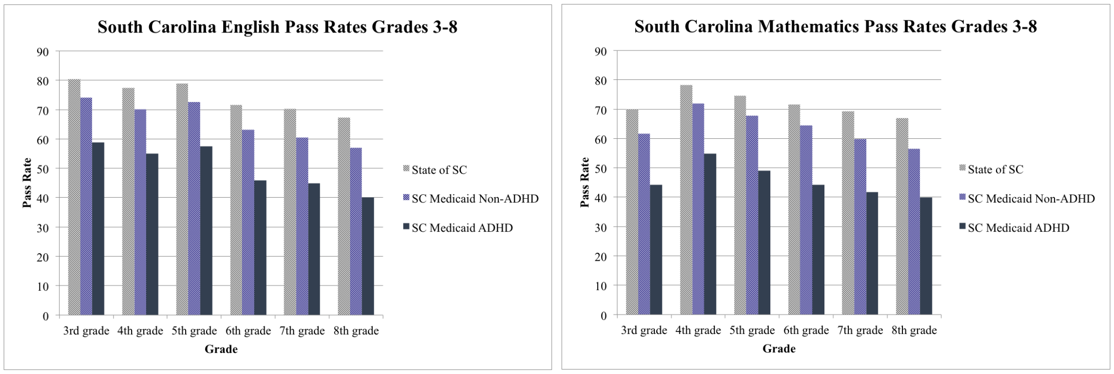
Attention-deficit/hyperactivity disorder is associated with lower reading and math standardized test scores, increased grade retention, and an increased probability of being placed in special education (Loe and Feldman (2007); Currie and Stabile (2006)). Figure 1.1 shows the passing rates for South Carolina students' 3rd through 8th grade standardized tests in English and mathematics. Passing rates are shown for the state of South Carolina, our Medicaid sample that is not diagnosed with ADHD, and our Medicaid sample diagnosed with ADHD. Consistent with these prior studies, South Carolina Medicaid data show that individuals diagnosed with ADHD are less likely to meet the state requirements relative to South Carolina Medicaid individuals not diagnosed with ADHD. Not surprisingly, relative to the state of South Carolina, the Medicaid sample has lower passing rates.[2]

Lower academic achievement for children diagnosed with ADHD can have long-run

[1] 2.37% of the sample is diagnosed with predominantly hyperactive-impulsive ADHD. Due to the small number of observations, we are unable to include this subgroup separately.

[2] Note: these are raw averages. Thus, we are not accounting income and parental educational differences in these calculations.

Figure 1.1: South Carolina Academic Performance



Notes: 3rd through 8th grade South Carolina Palmetto Assessment of State Standards (SCPASS) English and Math passing rates are presented. The passing rates are averaged across the years 2009-2013. State of SC represents the passing rates of all students in South Carolina (source: http://ed.sc.gov/data/test-scores/state-assessments/scpalmetto-assessment-of-state-standards-pass/). SC Medicaid Non-ADHD represents our sample of Medicaid children who have never been diagnosed with ADHD. SC Medicaid ADHD represents our sample of Medicaid children diagnosed with ADHD.

implications and has been shown to translate into worse labor market outcomes. Fletcher (2014) finds that individuals diagnosed with ADHD are 10 percentage points less likely to participate in the labor market. Further, individuals diagnosed with ADHD experience an earning reduction of approximately 30% and are 15 percentage points more likely to receive social assistance.[3]

Although the mechanism of why children diagnosed with ADHD experience lower academic performance is not fully understood, ADHD symptoms of inattentiveness, hyperactivity and impulsivity in the classroom are believed to be a contributing factor (Barkley (2006)). If ADHD medication has the potential to improve academic performance through mitigation of symptoms, it can be viewed as a type of investment in human capital. Costs associated with ADHD medication are both pecuniary and non-pecuniary, due to the susceptibility of side effects such as loss of appetite, weight loss, irritability/anger, insomnia, headache, stomachache, and dizziness (Barkley (2006); Cascade et al. (2010)). On the other hand, these side effects can have detrimental effects on academic performance.

[3]The results are robust when including controls for comorbid health conditions, years of schooling, and family background. Earnings are conditional on non-zero earnings.

1.2.3 The Effects of ADHD Medication

There is a consensus that ADHD medication treatment is effective in mitigating the core symptoms of ADHD (Swanson et al. (1993), Barkley (2006), MTA (1999)), yet results on the effects of ADHD medication treatment on academic performance are inconclusive. Swanson et al. (1993) reviews 336 studies regarding the effects of ADHD medication on children diagnosed with ADHD. The review showed a consensus that medication treatment produces immediate symptomatic improvement of inattentiveness and hyperactivity. Importantly, the review agreed that the documented effects of medication on academic achievement and long-term effects are negligible.

ADHD medication studies that use measures of teacher opinion conclude that ADHD medication improves academic achievement of children. Barkley and Cunningham (1978) further explore these studies and find that when these studies use more objective measures of academic performance, there is little evidence of positive short-term or long-term effects. Instead, the major effect of ADHD medication appears to be an improvement in classroom manageability rather than the individual's own academic performance.

The Multimodal Treatment Study of Children with ADHD (MTA) is one of the first studies to investigate the short-term effects of ADHD treatment strategies in a clinical setting. The study randomly assigned 14 months of medication, behavioral therapy treatment, medication and behavioral treatment combined, or community care to 579 children between the ages of 7 and 9.9 years old. Children assigned to community care could receive treatments from community providers and, although it was used as the control group, 67.4% received medication treatment. The study concludes that the combination of medication and behavior therapy was most effective in reducing hyperactive and inattentive symptoms but finds no significant differences for academic achievement. A follow-up study conducted by Molina et al. (2009) investigates the effects of treatment and behavioral therapy eight years following the initial assignment of treatment. The researchers find that the groups do not differ significantly in behavioral or academic outcomes.

Currie et al. (2014) make use of a policy change that expanded insurance coverage for prescription medications in the province of Quebec, Canada. First they find that the policy increased the use of ADHD medications by 2.5 percentage points in Quebec in comparison to the rest of Canada. They find that the policy change is associated with worse outcomes in the short and longer-run. In particular, after the policy change girls experienced reductions in their math scores, were less likely to have a post-secondary education, and experienced a deterioration in parental relationships. For boys, the policy change was associated with an increase in grade repetition but the authors note that this result could be driven by the fact that Quebec was increasing their use of grade repetition for boys.

Dalsgaard et al. (2014) use Danish registry data and hospital level variation in propensities to prescribe pharmacological treatment to measure the causal effects of ADHD medication treatment on children's health and criminal outcomes. In a prior version of their paper, they investigated school outcomes. They note that only 40% of their sample takes the exit exam compared to the population mean of 95%. They find that ADHD medication harms children's academic performance measured by a decrease in the likelihood of taking the exit exam. Conditional on taking the exit exam, they find no statistically significant difference between the treated and untreated children.

This paper contributes to the literature by identifying the causal effects of ADHD medication treatment on short and longer-run educational outcomes for children and adolescents. To our knowledge, our paper is the first to consider heterogeneous treatment effects based on ADHD subtypes: combined inattentive and hyperactive/impulsive ADHD versus predominately inattentive ADHD. An advantage of our sample is that in South Carolina all students, including students with disabilities, are required to participate in standardized tests. We instrument for ADHD medication treatment with physician propensity to prescribe to address the endogeneity of ADHD medication treatment following Duggan (2005), Dalsgaard et al. (2014), and Chorniy and Kitashima (2015).

1.3 Data and Descriptive Statistics

We merge South Carolina Medicaid claims with data on student academic performance over the years 2003 to 2013. The dataset includes individuals diagnosed with ADHD between the ages of 3-18.

The Medicaid claims data include basic demographic information collected to determine Medicaid eligibility and a complete set of health services utilization records for all individuals: hospital, outpatient, and pharmacy claims. It is supplemented by several variables from the enrollees' birth certificates including mother's age, race, and education. Following earlier research work that used Medicaid or other administrative claims data (e.g. Frank et al. (2004)), we compile a set of ICD-9 diagnosis codes to identify individuals diagnosed with ADHD.[4] Pharmacy claims are used to track all prescription medications that were filled by a patient and to construct our instrumental variable (see Section 2.4).

The Department of Education data include measures of student performance: elementary and middle school test scores (South Carolina Palmetto Assessment of State Standards), high school exit exams (High School Assessment Program), and grade repetition.[5] The dataset includes information on learning disabilities, whether the individual qualifies for the free or reduced price lunch program, and whether the individual is English proficient.[6] School specific information include de-identified school IDs, school type, the district of the school, as well as school quality measures including student-to-teacher ratios, fraction of teachers with an advanced degree, and spending per student.

Of the original 145,264 individuals who had at least one ADHD-related claim between 3 and 18 years old, we extract all individuals for whom we were able to identify

[4]The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes are used by Medicaid for reporting purposes.

[5]South Carolina Palmetto Assessment State Standards includes testing in subjects of English, math, science, social studies, and writing.

[6]If a student has a registered learning disability through the school, they may qualify for special education services. For robustness, we exclude individuals with registered learning disabilities. Results reported in Section 2.7.

their first ADHD diagnosis.[7,8] Next we eliminate individuals with missing demographic information and individuals for whom we are unable to construct the instrument, provider propensity to prescribe. Because we define treatment as treated within a year of the individual's ADHD diagnosis, we condition on individuals being consistently eligible for Medicaid for at least one year.[9] Our final Medicaid sample diagnosed with ADHD includes 58,685 ADHD individuals.

For our analysis, we first investigate ADHD medication treatment effects by gender. Consistent with national statistics (Visser et al. (2014)) males make up 66% of the sample. We further consider heterogenous ADHD medication treatment effects based on gender and ADHD subtype classification based on symptoms: combined inattentive and hyperactive/impulsive ADHD (combined-ADHD) versus predominantly inattentive ADHD (PI-ADHD). Approximately 74% of the sample has combined-ADHD while 24% has PI-ADHD.[10]

Table 3.2 reports summary statistics on individual, mother, and family composition characteristics. Column (1) reports summary statistics by gender. Columns (2) and (3) report summary statistics based on ADHD subtype classification and by gender. Relative to the combined-ADHD sample, white females and males make up a larger proportion of the PI-ADHD sample. On average females are diagnosed at an older age than males. Both males and females diagnosed with PI-ADHD are diagnosed at a relatively older age than individuals diagnosed with combined-ADHD. Prior to the individuals' ADHD diagnoses, we observe that both females and males with combined-ADHD are more likely to be diagnosed

[7] Based on Crawford and Shum (2005), we exclude patients who have an ADHD-related claim within 180 days from their first appearance in the sample and patients who fill a prescription prior to their first observed ADHD-related provider visit. This requirement is necessary to construct the instrumental variable which uses individual's diagnosing physician propensity to prescribe. See Section 2.4.

[8] The original sample makes up approximately 20% of the children in the state.

[9] On average, we observe every Medicaid enrollee for eight years. Nearly 48% of the enrollees have at least one lapse in eligibility that exceeds two months, with the median lapse in coverage of eight months. For lapses in eligibility that last under three months, we assume that patients are enrolled but receive no medical treatment. For inconsistent eligibility periods that result in longer lapses in coverage, we only keep medical history prior to the lapse.

[10] 2% of the sample has predominantly hyperactive ADHD. For our main analysis we exclude these individuals. For robustness, we group them into the combined hyperactive/inattentive group. Results available upon request.

with a comorbid psychiatric condition.[11]

For our main specification, we consider the individual treated if they fill a prescription within a year of their ADHD diagnosis. Under this definition of treatment, males are more likely to be treated with ADHD medication. Both females and males with combined-ADHD take a higher intensity of treatment as shown by both the percentage of the sample filling six or more prescriptions within a year and the average number of prescriptions filled.[12]

Across gender and ADHD subtype classifications, the households primarily consist of a single adult and two children. On average, individuals with PI-ADHD have a relatively higher reported monthly household income than individuals with combined ADHD. In-state birth certificates are matched to 73% of children in our sample providing data on mother's education and age when she gave birth.[13] The majority of mothers in the sample have only some high-school education (36.8%) or a high school diploma (40.1%).

Table 2.2 reports summary statistics on the academic performance measures used in our analysis. Column (1) reports summary statistics by gender. Columns (2) and (3) report summary statistics based on ADHD subtype classification and by gender. The test score outcomes are defined as the probability of passing both the English and mathematics examinations.[14,15,16] We pool observations by grades to categorize test score outcomes in terms of elementary school, middle school, and high school.[17] For grade repetition, we report summary statistics for each individual/school year. Means can be interpreted as the

[11]Common comorbid conditions associated with ADHD include oppositional defiant disorder, depression, anxiety and bipolar disorder. The results are robust when we control for comorbid conditions that appear prior the individual's ADHD diagnosis.

[12]Average number of prescriptions filled is conditional on an individual filling at least one prescription while observed in Medicaid.

[13]The number of observations matched with birth certificate data are represented by the number of observations in parentheses.

[14]For elementary and middle school examinations, we observe the individual's test score on a 1 to 5 rating. For high school examinations, we only observe if the individual passes or fails the exam. For ease of interpretation, in our primary specification all test scores can be interpreted as the probability of passing the English and mathematics examinations.

[15]For individuals who take the exam more than once, we take their test score from their first attempt.

[16]Other subjects in the dataset include science, social studies and writing test scores (results available upon request).

[17]Elementary school includes observations in third, fourth and fifth grade, and middle school includes observations in sixth, seventh and eighth grade.

Table 1.1: Summary Statistics: Individual and Family Characteristics

	All ADHD Sample (1)				Combined ADHD (2)				Predominantly Inattentive (3)			
	Female		**Male**		**Female**		**Male**		**Female**		**Male**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Individual characteristics												
Race: White	0.515		0.463		0.494		0.449		0.578		0.512	
Black	0.397		0.423		0.418		0.433		0.343		0.391	
Hispanic	0.020		0.027		0.019		0.028		0.022		0.027	
Other	0.067		0.086		0.069		0.090		0.057		0.069	
Comorbid Condition	0.446		0.463		0.454		0.470		0.415		0.426	
ADHD symptoms and treatment												
Age of ADHD diagnosis	8.412	3.596	7.753	3.370	8.108	3.515	7.520	3.267	9.297	3.659	8.682	3.537
Treatment: Baseline	0.679		0.734		0.673		0.736		0.696		0.729	
6+ Rx	0.477		0.544		0.539		0.611		0.498		0.552	
Avg N RX	5.392	4.497	5.882	4.684	5.663	4.674	6.071	4.771	4.711	3.954	5.208	4.284
Family & home environment												
Monthly fam income	585.634	800.515	604.554	800.088	568.447	786.681	583.293	788.673	643.014	836.887	687.256	836.966
N adults	1.011	0.737	1.009	0.722	0.987	0.728	0.993	0.718	1.089	0.749	1.080	0.728
N children	2.080	1.114	2.132	1.127	2.083	1.119	2.127	1.129	2.090	1.104	2.164	1.121
Mother's characteristics												
Age when gave birth	23.489	5.540	23.372	5.427	23.472	5.525	23.345	5.387	23.454	5.557	23.379	5.520
Educ: Less than HS	0.049		0.048		0.050		0.048		0.049		0.049	
Some HS	0.375		0.365		0.384		0.373		0.356		0.340	
HS diploma	0.399		0.402		0.391		0.398		0.417		0.420	
Some college	0.127		0.133		0.128		0.131		0.125		0.137	
College degree or higher	0.050		0.053		0.049		0.052		0.053		0.053	
N obs. (w/ mother info)	19,839	(14,113)	38,835	(28,570)	13,893	(10,032)	29,296	(21,746)	5,493	(3,744)	8,601	(6,117)

Notes: The sample includes SC Medicaid enrollees diagnosed with ADHD between 3 and 18 years old in 2003-2013 and who were eligible for Medicaid at least one year after this event. Family characteristics are averaged per patient/eligibility year. Mother characteristics are reported based on in-state birth certificate information matched to Medicaid records and are available only for a subsample denoted by number of observations in parentheses. Mother's age and educational attainment are recorded at the time of the child's birth. "HS" stands for high school education level.

percent of the sample that repeats a grade in a given year.

Compared to males, females perform better throughout their school careers in terms of higher probability of meeting English and mathematics examination requirements and lower rates of grade repetition. Nearly 6.4% of females repeat a grade and approximately 8% of males repeat a grade each year. Across gender and ADHD subtype classification, we observe that aside from elementary school, females diagnosed with PI-ADHD perform better on test scores than females diagnosed with combined-ADHD. Relative to males diagnosed with combined-ADHD, males diagnosed with PI-ADHD perform better on test scores across their school careers.

Table 1.2: Summary Statistics: Academic Performance Measures

	All ADHD Sample (1)		**Combined ADHD (2)**		**Pred Inatt ADHD (3)**	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**
Probability of passing English & mathematics						
Elementary School Test Scores	0.412	0.411	0.417	0.409	0.396	0.418
N obs	20,238	39,743	14,860	31,071	5,378	8,672
Middle School Test Scores	0.338	0.303	0.335	0.302	0.347	0.307
N obs	16,985	31,254	11,636	23,114	5,349	8,140
High School Test Scores	0.553	0.486	0.540	0.475	0.575	0.509
N obs	2,770	4,503	1,783	3,117	987	1,386
Grade Repetition	0.064	0.081	0.064	0.080	0.064	0.081
N obs	61,292	117,610	44,256	90,572	17,036	27,038

Notes: Test scores are interpreted as the probability of passing both the English and mathematics examinations. Observations are pooled by grades to categorize test score outcomes in terms of elementary school, middle school, and high school. Grade repetition can be interpreted as the percent of the sample that repeats a grade in a given year.

1.4 Empirical Model

To estimate the causal relationship between academic performance and ADHD medication, we estimate the following model using our subsample of individuals diagnosed with ADHD:

$$Y_i = \alpha_0 + \alpha_1 Treated_i + X_i\alpha_2 + Mother_i\alpha_3 + Family_i\alpha_4 + Location_i\alpha_5 + Year_t\alpha_6 + \varepsilon_i \quad (1.1)$$

where Y_i represents an academic performance measure; $Treated_i$ takes a value of one if the individual fills at least one ADHD prescription within a year of their ADHD diagnosis and zero otherwise; X_i is a vector of individual-level observables which includes gender, race, birth year, year of ADHD diagnosis, and comorbid psychiatric conditions;[18] $Mother_i$ represents maternal education and maternal age of birth; $Family_i$ includes controls for number of children and adults in the household as well as family income; $Location_i$ represents either the county of diagnosis or school the individual is enrolled in at the time of the outcome, $Year_t$ represents the school year. Our main coefficient of interest is α_1, which can be interpreted as the mean difference in outcomes across the treated and non-treated ADHD diagnosed groups.

Because ADHD medication is not randomly assigned to individuals, $Treated$ is likely correlated with ε: unobserved factors that make some individuals more likely to receive treatment also influence their academic performance. For example, parental characteristics such as more attentive parenting may increase the likelihood that a parent pursues treatment for their child. Better outcomes for this child may reflect the attentive parenting rather than the effect of ADHD medication.

[18] We control for comorbid psychiatric conditions that the individual was diagnosed with prior to their ADHD diagnosis.

1.4.1 Identification

Following Duggan (2005), Dalsgaard et al. (2014) and Chorniy and Kitashima (2015), we instrument for ADHD medication treatment receipt using diagnosing providers' propensity to prescribe. An individual's probability of treatment receipt is dependent on whether the individual is diagnosed by a relatively high-prescribing doctor or low-prescribing doctor.

$$\text{PropPresc}_{dt,\sim i} = \frac{\text{N patients treated}_{dt} - 1 * (\text{Treated}_{idt} = 1)}{\text{N patients}_{dt} - 1} \tag{1.2}$$

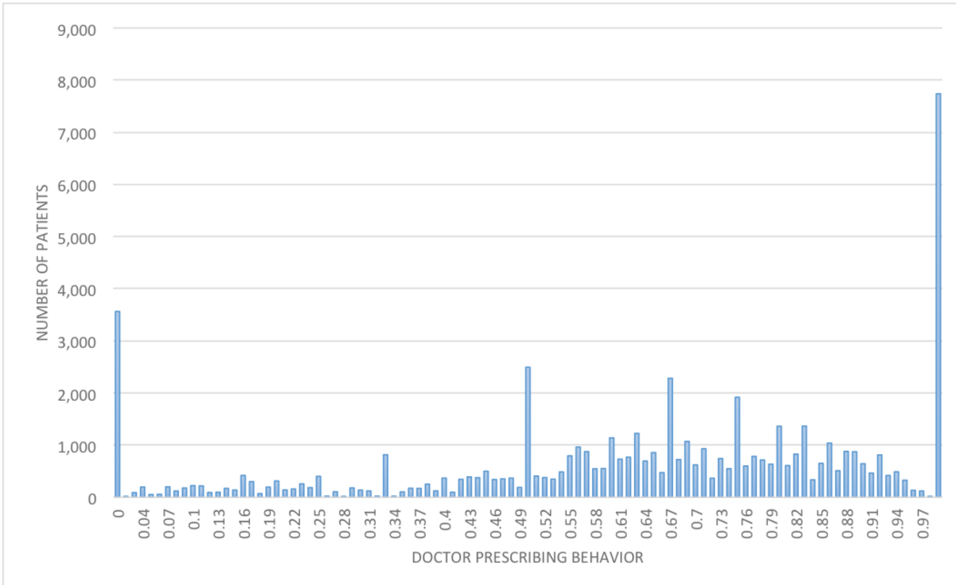
For each individual i, we construct doctor propensity to prescribe treatment by calculating the fraction of other patients that receive treatment from individual i's diagnosing provider d in year t. Specifically, we subtract the focal individual's treatment status (0,1) from the number of patients treated with medication by doctor d in year t, and divide by the total number of other patients diagnosed with ADHD by doctor d in year t.

In our Medicaid pharmaceutical claims data, we only observe prescriptions filled by the individual. Thus, the diagnosing provider's propensity to prescribe reflects both the probability that the provider writes a prescription and the probability that the patient fills the prescription (Dalsgaard et al. (2014)).[19]

Figure 2.2 shows the distribution of provider propensity to prescribe in our dataset. Variation in physician propensity to prescribe can in part be explained by variation in physicians' views on the effectiveness of medication and severity of side effects. Stockl et al. (2002) surveys 1,000 physicians who prescribe ADHD medication and finds considerable variation in physicians perception regarding the severity of medication side effects, the effectiveness of medication, and concerns about the medication being used for purposes

[19] Both the probability that a provider prescribes medication to the patient and the probability that the patient fills the prescription, conditional on the provider's engagement with the patient, is relevant variation for our analysis.

Figure 1.2: Distribution of Provider Propensity to Prescribe



Notes: The figure shows the distribution of the probability that a patient receives a prescription from a particular physician in the year of their diagnosis based on the sample of 58,674 ADHD-diagnosed patients enrolled in SC Medicaid in 2003-2013. Provider prescribing behavior varies from zero to one.

other than patient's medical needs.[20]

The first stage equation measures the relationship between provider propensity to prescribe and ADHD medication treatment receipt given by Equation 2.4.

$$Treated_i = \delta PropPresc_{dt,\sim i} + X_i\gamma_1 + Mother_i\gamma_2 + Family_i\gamma_3 + Location_i\gamma_4 + Year_t\gamma_5 + \nu_i \tag{1.3}$$

where the instrument $PropPresc_{dt,\ i}$ is a patient-specific probability to receive a prescription from the provider who diagnosis the individuals with ADHD, excluding the focal individual; X_i, $Mother_i$ and $Family_i$ are the same vector of controls listed above. $Treated_i$ is equal to one if the individual receives ADHD medication treatment within 365 days of their ADHD diagnosis and zero otherwise.[21] We include academic outcome measures that occur

[20]Physician prescribing practices were found to vary with the reimbursement mechanism (Dickstein, 2014) and their individual preferences (Hellerstein (1998))

[21]For robustness, we redefine treatment as the fraction of Medicaid eligible years the individual takes ADHD medication after their ADHD diagnosis. We use IV probit maximum likelihood models to obtain estimates, reported in Table 12.

a year or more after the individual's ADHD diagnosis, assuring that treatment predates the educational outcome. A required assumption is that doctor prescribing behavior only has an effect on treatment receipt within a year of the individual's ADHD diagnosis (and has no effect on outside treatment channels).[22]

After estimating Equation 2.4, Equation 1.4 estimates the causal effect of ADHD medication treatment on test scores and Equation 1.5 estimates the causal effect of ADHD medication treatment on grade repetition.

$$TestScore_{ig} = \alpha_0 + \alpha_1 \widehat{Treated}_i + X_i\alpha_2 + Mother_i\alpha 3 + Family_i\alpha_4 + Location_{ig} + Year_g + \varepsilon_i \tag{1.4}$$

The effects of ADHD medication on primary and secondary students' test scores are measured by Equation 1.4. We utilize a cross-sectional analysis with individual i in grade g as the unit of observation. $TestScore_{ig}$ represents the test score of individual i in grade g.[23] $\widehat{Treated}_i$ is the predicted treatment from Equation 2.4. α_1 is the variable of interest and can be interpreted as the effect of being treated within a year of the individual's ADHD diagnosis on the individual's test score. $Location_{ig}$ is a control for the school the individual attends in grade g, and $Year_g$ is a school year control.

In Equation 1.5, we measure the effects of ADHD medication on grade repetition. We make use of our panel data which allows us to control for the individual's grade, school, school year specific trends as well as other time-varying factors that could have an effect on grade repetition.

$$Repeatgrade_{it} = \beta_0 + \beta_1 \widehat{Treated}_i + X_i\beta_2 + Z_{it}\beta_3 + Location_{it} + Year_t + Grade_t + \varepsilon_{it} \tag{1.5}$$

where $Repeatgrade_{it}$ represents whether the individual repeated a grade in year t. One important thing to note is that the instrument doctor propensity to prescribe is constructed

[22] Section 2.5 provides further discussion on the validity of our instrumental variable.

[23] Test score measures can be interpreted as the probability of passing both the English and mathematics examinations.

for the year of the individual's ADHD diagnosis and is not time varying. Thus, $\widehat{Treated}_i$ is the predicted treatment from Equation 2.4 as in the cross-sectional analysis. β_1 is the variable of interest and can be interpreted as the effect of being treated within a year of the individual's ADHD diagnosis on the probability of repeating a grade in a given year.

In Equations 1.4 and 1.5, the standard errors are clustered on provider ID to allow for the possibility of correlation across observations for observations that share the same diagnosing provider. Estimation of Equation 1.4 and Equation 1.5 will be consistent provided that $PropPresc_i$ influences treatment and is uncorrelated with the error terms ε_i and ε_{it}. We provide supporting evidence of our identification strategy in Section 2.5.

1.5 IV Validity

In order for our instrument to be valid, the instrument must both be a strong predictor of ADHD medication treatment receipt and also be uncorrelated with the unobserved factors determining students' academic performance.

1.5.1 First Stage Results

Table 1.3 reports the first stage results. Column (1) reports first stage results by gender. Columns (2) and (3) report first stage results by ADHD subtype classification and by gender. Covariates include: the individual's gender, race, comorbid psychiatric conditions diagnosed prior to the individual's ADHD diagnosis, birth year, year of ADHD diagnosis, school location controls, mother's age and education, family income, number of children and number of adults in the household. In column (1) the coefficients on provider propensity to prescribe can be interpreted as a 10 percentage point increase in provider propensity to prescribe increases the probability of ADHD medication treatment receipt 3.9 percentage points for females and 3.33 percentage points for males. The three columns show that provider propensity to prescribe has explanatory power for treatment receipt for all subsamples we investigate and does not suffer as a weak instrument.

Table 1.3: First Stage Results

	All ADHD Sample (1)		Combined ADHD (2)		Pred Inatt ADHD (3)	
Dependent Variable: ADHD Treatment	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
Provider Propensity to Prescribe	**0.390*****	**0.333*****	**0.404*****	**0.330*****	**0.309*****	**0.294*****
	(0.017)	**(0.012)**	**(0.021)**	**(0.014)**	**(0.037)**	**(0.027)**
Race: Black	-0.051***	-0.038***	-0.049***	-0.038***	-0.080***	-0.041**
	(0.010)	(0.007)	(0.012)	(0.008)	(0.023)	(0.016)
Hispanic	-0.222***	-0.086***	-0.251***	-0.114***	-0.192**	0.033
	(0.048)	(0.030)	(0.059)	(0.035)	(0.098)	(0.066)
Other	-0.057**	-0.062***	-0.054**	-0.064***	-0.035	-0.044
	(0.022)	(0.013)	(0.026)	(0.015)	(0.051)	(0.034)
School Controls	Y	Y	Y	Y	Y	Y
Mother & individual characteristics	Y	Y	Y	Y	Y	Y
R^2	0.282	0.201	0.336	0.223	0.434	0.326
N	11,322	22,002	7,916	16,587	3,190	5,003

Notes: The dependent variable is an indicator equal to 1 if treated with ADHD medication within 365 days of diagnosis. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

1.5.2 Exclusion Restriction

1.5.2.1 IV Correlation with Observables

The assumption that doctor propensity to prescribe is not correlated with the unobservable determinants of academic outcomes cannot be tested. However, if we find a relationship between the instrument and an important set of observables, we may be concerned that the instrument is also correlated with unobservables. As a check for the assumption that our instrumental variable is uncorrelated with unobserved factors determining students' academic performance, we conduct balancing tests by regressing the instrument provider propensity to prescribe on a set of observables as presented in Equation 1.6.

$$PropPresc_i = \alpha_0 + X_i\alpha_1 + Mother_i\alpha_2 + Family_{it}\alpha_3 + \mu_{it} \tag{1.6}$$

where X is a vector of child characteristics including psychiatric conditions that the individual was diagnosed with prior to their ADHD diagnosis, $Mother$ represents mother characteristics including the mother's age when she gave birth and the mother's education, $Family$ represents family characteristics in the year of the individual's diagnosis including number of adults and number of children in the household in addition to family net income.

Table 1.4 presents estimated coefficients and F-tests of joint significance of these covariates in each specification. If higher educated mothers choose relatively higher prescribing physicians, unobserved mother characteristics correlated with mother's education could bias our results towards finding that medication has positive effects on children's academic performance. Column (1) reveals that doctor prescribing behavior is not correlated with mother's education or mother's age when she gave birth. In column (2), we add family composition and income controls and find that number of adults in a household and family income is not correlated with doctor propensity to prescribe. We do find a small, economically insignificant correlation between number of children in a household and doctor propensity to prescribe. The interpretation of this coefficient is increasing the number of children in a family from one to two is associated with an increase in doctor propensity to prescribe of 0.27 percentage points. The coefficients on the mother's characteristics, family composition, and income are jointly insignificant.

We next consider the plausibility of individuals diagnosed with other psychiatric conditions being more likely to visit physicians with relatively high propensity to prescribe ADHD medication. Column (3) shows evidence that there is no correlation between an individual having a psychiatric condition and doctor propensity to prescribe.[24]

Because most families on Medicaid are relatively poor, there is little income variation in this population group. As an alternative measure of income, column (4) includes indicators for free lunch and reduced price lunch receipt. The results show that there is no correlation between free or reduced price lunch receipt and doctor propensity to prescribe.

1.5.2.2 Placebo Test

The exclusion restriction would be violated if doctor propensity to prescribe has an effect on individuals' academic performance through an alternative channel, outside of treatment receipt. For example, if relatively lower prescribing physicians are more likely to suggest other academic interventions, it could lead to a downward bias in the effects of

[24] Psychiatric conditions are considered if the individual is diagnosed prior to their ADHD diagnosis.

Table 1.4: Instrument Correlation with Observables

Dependent Variable: Doctor PTP	**(1)**	**(2)**	**(3)**	**(4)**
Mother's educ: Less than HS	-0.0003	-0.0008	-0.0008	-0.0004
	(0.006)	(0.006)	(0.006)	(0.006)
Some HS	-0.0033	-0.0037	-0.0037	-0.0033
	(0.003)	(0.003)	(0.003)	(0.003)
Some college	-0.0039	-0.0035	-0.0035	-0.0038
	(0.004)	(0.004)	(0.004)	(0.004)
College degree	0.0010	0.0016	0.0016	0.0016
	(0.006)	(0.006)	(0.006)	(0.006)
Mother's age at birth	-0.0002	-0.0002	-0.0002	-0.0002
	(0.000)	(0.000)	(0.000)	(0.000)
N adults		0.0023	0.0024	0.0014
		(0.002)	(0.002)	(0.002)
N children		0.0028**	0.0028**	0.0026**
		(0.001)	(0.001)	(0.001)
Family income		-0.0025	-0.0025	–
		(0.002)	(0.002)	–
Mental Condition			0.0005	0.0005
			(0.003)	(0.003)
Free lunch				0.0033
				(0.003)
Reduce lunch				0.0054
				(0.006)
County FE	Yes	Yes	Yes	Yes
N	41,099	41,099	41,099	41,099
Joint F-Stat (excluding county FE)	0.54	1.46	1.31	1.09
p-value	0.75	0.16	0.23	0.37

Notes: The dependent variable is the instrument provider propensity to prescribe. The omitted mother educational category is mothers with a high school degree. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses.

ADHD medication on academic performance.

We devise a placebo test by making use of a sample of South Carolina Medicaid children who were never diagnosed with ADHD (labeled undiagnosed). Because the undiagnosed sample of children cannot receive ADHD medication treatment, we test to see if doctor propensity to prescribe has a direct relationship with academic performance outcomes outside of the treatment receipt channel. For the undiagnosed sample, we first identify their provider at age 8, which is the mean age of when an individual is diagnosed with ADHD in our sample. We construct a measure of doctor propensity to prescribe ADHD medication for an individual who never is diagnosed with ADHD by using that provider's prescribing patterns to ADHD patients. Table 1.5 reports results for the undiagnosed sample. For comparison, Table 1.5 also reports the reduced form regression coefficients for children diagnosed with ADHD.

Referring to Panel A, for the sample never diagnosed with ADHD we find that doctor propensity to prescribe ADHD medication is not correlated with elementary, middle school, or high school test scores and has no relationship with grade repetition. These findings suggest that the instrument doctor propensity to prescribe has no direct effect (outside of treatment receipt) on academic outcomes for the undiagnosed sample who cannot receive ADHD medication. In comparison, Panel B shows that the reduced form estimates, that regress academic outcomes on doctor propensity to prescribe for the ADHD sample, show a negative correlation for female's middle school and high school test scores. The reduced form estimates also show a positive relationship between doctor propensity to prescribe and grade repetition. The results are suggestive evidence in favor of doctor propensity to prescribe as a valid instrument.

Table 1.5: Placebo Test

	Elementary Test Scores		Middle School Test Scores		High School Test Scores		Grade Repetition	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
Panel A. Undiagnosed Sample								
Doctor Propensity to Prescribe	**0.011**	**0.011**	**0.031**	**0.028**	**0.040**	**0.038**	**-0.003**	**0.002**
	(0.022)	(0.024)	(0.026)	(0.029)	(0.037)	(0.040)	(0.003)	(0.004)
Race: Black	-0.191***	-0.225***	-0.165***	-0.236***	-0.134***	-0.193***	0.004**	0.009***
	(0.012)	(0.013)	(0.015)	(0.017)	(0.020)	(0.022)	(0.002)	(0.002)
Hispanic	-0.037	-0.081**	-0.025	0.011	0.020	0.053	-0.004	-0.009
	(0.038)	(0.039)	(0.052)	(0.056)	(0.055)	(0.071)	(0.006)	(0.007)
Other	-0.053*	-0.035	-0.124***	-0.063	-0.015	-0.087*	0.004	-0.005
	(0.032)	(0.033)	(0.045)	(0.048)	(0.052)	(0.052)	(0.005)	(0.006)
N child	-0.014***	-0.004	-0.020***	-0.004	-0.011	0.014	0.003***	0.004***
	(0.005)	(0.005)	(0.006)	(0.007)	(0.007)	(0.009)	(0.001)	(0.001)
Free lunch	-0.009	-0.055***	-0.037**	-0.039*	0.007	0.016	0.002	0.001
	(0.016)	(0.017)	(0.018)	(0.021)	(0.021)	(0.025)	(0.002)	(0.003)
Mean	0.625	0.574	0.523	0.454	0.732	0.674	0.026	0.039
N obs.	9,896	8,947	6,253	5,140	2,759	2,288	50,030	42,455
R^2	0.162	0.168	0.188	0.199	0.191	0.235	0.129	0.155
Panel B. ADHD Diagnosed Sample								
Doctor Propensity to Prescribe	**-0.020**	**0.005**	**-0.095*****	**0.005**	**-0.100*****	**-0.004**	**0.014*****	**0.008****
	(0.018)	(0.014)	(0.020)	(0.014)	(0.031)	(0.028)	(0.005)	(0.004)
Race: Black	-0.198***	-0.196***	-0.188***	-0.196***	-0.167***	-0.192***	0.014***	0.012***
	(0.011)	(0.008)	(0.012)	(0.008)	(0.020)	(0.017)	(0.003)	(0.003)
Hispanic	-0.067	-0.071*	0.100	-0.071*	-0.055	0.010	-0.043***	-0.004
	(0.050)	(0.042)	(0.076)	(0.042)	(0.101)	(0.068)	(0.015)	(0.013)
Other	-0.069***	-0.107***	-0.067**	-0.107***	-0.090*	-0.149***	0.007	0.015**
	(0.026)	(0.015)	(0.026)	(0.015)	(0.048)	(0.034)	(0.008)	(0.006)
N child	-0.011**	-0.009***	-0.006	-0.009***	-0.009	-0.005	0.004***	0.004***
	(0.005)	(0.003)	(0.005)	(0.003)	(0.009)	(0.007)	(0.001)	(0.001)
Free lunch	-0.028	-0.061***	-0.043**	-0.061***	-0.030	-0.057***	-0.004	0.003
	(0.017)	(0.013)	(0.017)	(0.013)	(0.028)	(0.022)	(0.004)	(0.004)
Mean	0.406	0.403	0.322	0.290	0.560	0.498	0.060	0.077
N	14,071	29,185	12,340	29,185	2,693	4,365	45,659	89,478
R^2	0.145	0.151	0.153	0.151	0.193	0.179	0.209	0.216

Notes: Panel A and B show results of the placebo IV validity test. The dependent variable in each specification is one of the academic outcomes. In Panel A, provider propensity to prescribe is constructed using the undiagnosed individual's provider at the mean age of an ADHD diagnosis. Panel B reports the reduced form coefficients (for the sample of individuals diagnosed with ADHD). Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses.

1.6 Results

We first examine the effects of ADHD medication treatment by gender in Section 1.6.1. Table 1.6 reports the coefficients of ADHD medication treatment on elementary, middle, and high school test scores and Table 1.7 reports the coefficients of ADHD medication treatment on grade repetition by gender.

We next stratify the sample by gender and ADHD subtype (see Section 1.2.1). Table 1.8 reports the coefficients of ADHD medication treatment on elementary, middle, and high school test scores and Table 1.9 reports the coefficients of ADHD medication treatment on grade repetition by gender and symptoms. Figures 1.3 and 1.4 plot the effects of ADHD medication treatment on test scores for each individual grade (for elementary and middle school) to determine if a particular grade year is driving the results and to observe the effects of medication over the progression of the individual's school career. The results are presented in Figure 1.3 and Figure 1.4 for combined hyperactive/inattentive ADHD and predominantly inattentive ADHD samples, respectively.

To summarize the results, we pool observations by grades to categorize test score outcomes in terms of elementary, middle and high school.[25] In these regressions, school year and the individual's grade are used as controls. For ease of interpretation, the test score outcomes are defined as the probability of passing both the English and mathematics examinations.[26]

1.6.1 By Gender

1.6.1.1 Test Scores

Table 1.6 presents the results of ADHD medication treatment on elementary, middle, and high school test scores for females (Panel A.) and males (Panel B.). The estimates show that females who take ADHD medication are less likely to pass both the English

[25]Elementary school includes observations in third, fourth and fifth grade, and middle school includes observations in sixth, seventh and eighth grade.

[26]For elementary and middle school examinations, we observe the individual's test score on a 1 to 5 rating. Results on English, mathematics and science test scores are reported in Table 6 in the appendix.

and mathematics examinations by 18 percentage points in middle school and 17 percentage points in high school. However, the estimated coefficients on ADHD medication treatment are small in magnitude and are not statistically significant for male students.

Appendix Tables 7 and 8 report the estimated coefficients of individual, mother, and family controls. The coefficients are the expected signs and are similar for females and males. Across elementary, middle and high school, black children are 17.1-20.1 percentage points less likely to pass both the English and mathematics examinations relative to white children. We control for comorbid psychiatric conditions that children are diagnosed with prior to their ADHD diagnosis. We find that children diagnosed with a psychiatric condition are 4.4-11 percentage points less likely to pass their examinations. The largest negative effect is for females in high school. Individuals in a household with a greater number of children perform slightly worse on their test scores and this effect appears to be largest in elementary school. For instance, going from a household with 1 to 2 children reduces the probability of passing both the English and mathematics examination by 0.7-1.1 percentage points. This is likely due to the fact that families with more children devote relatively less time to the individual child. Finally, children who have mothers with lower levels of education perform relatively worse on examinations.

1.6.1.2 Grade Repetition

Table 1.7 reports the results of ADHD medication treatment on grade repetition for females and males. Each school year, approximately 6% of females diagnosed with ADHD repeat a grade and 7.7% of males diagnosed with ADHD repeat a grade.[27] The results suggest that for students who take pharmaceutical treatment, the probability of repeating a grade increases by 2.8 percentage points for females and 1.9 percentage points for males in a given year.

The coefficients on covariates of interest are of expected signs and are similar across males and females. Blacks are more likely than whites to repeat a grade. Controlling for English

[27] In the undiagnosed Medicaid sample, we observe that 2.6% of females repeat a grade and 3.9% of males repeat a grade.

Table 1.6: ADHD Treatment Effects on Test Scores by Gender

	Elementary School		**Middle School**		**High School**	
	OLS	**IV**	**OLS**	**IV**	**OLS**	**IV**
Panel A. Female:						
Treatment	-0.061***	**-0.047**	-0.090***	**-0.180*** **	-0.075***	**-0.170*** **
	(0.011)	**(0.040)**	(0.012)	**(0.034)**	(0.019)	**(0.053)**
Mean	0.406		0.322		0.560	
N obs.	14,071		12,340		2,693	
R^2	0.148	0.148	0.158	0.150	0.195	0.233
Panel B. Male:						
Treatment	-0.001	**0.014**	-0.042***	**-0.036**	-0.027	**0.002**
	(0.007)	**(0.037)**	(0.009)	**(0.034)**	(0.016)	**(0.057)**
Mean	0.403		0.290		0.498	
N obs.	29,185		23,924		4,365	
R^2	0.151	0.151	0.136	0.136	0.179	0.178

Notes: The coefficient estimates in this table can be interpreted as the effect of ADHD medication within a year of the individual's ADHD diagnosis on the probability of passing both the English and mathematics examinations. All specifications include school controls, birth year, year of diagnosis, and school year controls. We also control for the individual's grade, comorbid psychiatric conditions, if the individual is English proficient, mother's age and education at birth, family income, number of children and adults in the household, and number of patients diagnosed by the individual's diagnosing provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

proficiency, Hispanic females are less likely to repeat a grade than white females. For both females and males, increasing children in the household from 1 to 2 increases the likelihood of grade repetition by 0.4 percentage points. Children who have mothers with lower levels of education are more likely to repeat a grade in a given year. Children who were diagnosed with a mental condition prior to their ADHD diagnosis are more likely to repeat a grade and the effect is larger for males (1.3 percentage points) than females (0.6 percentage points).

1.6.2 By Gender and ADHD Subtype

1.6.2.1 Test Scores

We next divide the sample by gender and ADHD subtype classification. Table 1.8 presents the OLS and IV estimates of ADHD medication treatment on elementary, middle and high school test scores. The rows specify the sub-samples: females diagnosed with combined inattentive and hyperactive/impulsive ADHD (Panel A.), males diagnosed with

Table 1.7: ADHD Treatment Effects on Grade Repetition by Gender

	Female		Male	
	OLS	**IV**	**OLS**	**IV**
Treatment	0.016***	**0.028*** **	0.005**	**0.019** **
	(0.003)	**(0.009)**	(0.002)	**(0.009)**
Race: Black	0.014***	0.015***	0.012***	0.012***
	(0.003)	(0.003)	(0.003)	(0.003)
Hispanic	-0.042***	-0.039**	-0.002	-0.000
	(0.016)	(0.015)	(0.012)	(0.012)
Other	0.006	0.007	0.015***	0.016***
	(0.008)	(0.008)	(0.006)	(0.006)
Num children in HH	0.004**	0.004**	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Mother's Educ: Less than HS	0.019***	0.019**	0.014**	0.014**
	(0.007)	(0.007)	(0.006)	(0.006)
Some HS	0.011***	0.011***	0.008***	0.008***
	(0.003)	(0.003)	(0.003)	(0.003)
Some college	-0.013***	-0.013***	-0.007**	-0.007**
	(0.004)	(0.004)	(0.003)	(0.003)
College degree	-0.007	-0.008	-0.007	-0.006
	(0.007)	(0.007)	(0.005)	(0.005)
Mental condition	0.006**	0.006*	0.013***	0.013***
	(0.003)	(0.003)	(0.002)	(0.002)
English proficient	-0.042**	-0.043**	-0.012	-0.012
	(0.018)	(0.018)	(0.014)	(0.014)
Mean	0.060		0.077	
N	45,659		89,478	
R^2	0.208	0.207	0.215	0.214

Notes: The coefficient estimates in this table can be interpreted as the effect of ADHD medication within a year of the individual's ADHD diagnosis on the probability of repeating a grade in a given year. All specifications include school controls, birth year, year of diagnosis, and school year controls. We also control for the individual's grade, comorbid psychiatric conditions, if the individual is English proficient, mother's age and education at birth, family income, number of children and adults in the household, and number of patients diagnosed by the individual's diagnosing provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

combined inattentive and hyperactive/impulsive ADHD (Panel B.), females diagnosed with predominantly inattentive ADHD (Panel C.), and males diagnosed with predominantly inattentive ADHD (Panel D.).[28]

We find that ADHD medication has negative effects for the subset of females diagnosed with combined inattentive hyperactive/impulsive ADHD (combined-ADHD). Specifically, we find that ADHD medication decreases the probability of passing both the English and mathematics exams by 20.2 percentage points in middle school and 19 percentage points in high school. For males diagnosed with predominantly inattentive ADHD (PI-ADHD), we find evidence that ADHD medication is beneficial in elementary school increasing the probability of passing both the English and mathematics exams by 17.8 percentage points. Interestingly, for males diagnosed with PI-ADHD we find no statistically significant effect of ADHD medication in middle school or high school suggesting that the effects of ADHD medication subside over these individuals' school career.

1.6.2.2 Test Scores by Grade

We next analyze the effects of ADHD medication on test score performance by running the regressions by grade to determine if the positive or negative effects of medication are driven by observations in a particular grade and to observe the effects of medication over the progression of the individual's school career. Human capital accumulation theory would predict that if ADHD medication improves academic performance, those improvements would carry into subsequent grades. Figure 1.3 and Figure 1.4 plot the coefficient estimates and confidence intervals of ADHD medication effects on the probability of passing the English and mathematics tests across grades.

Figure 1.3 presents the effects of ADHD medication treatment for females and males diagnosed with combined hyperactive/inattentive ADHD. The plot shows that ADHD medication impedes academic performance for females diagnosed with combined hyperactive/inattentive ADHD and the magnitude of the negative effect increases with each sub-

[28] For third through eighth grade, we have information on individual's test score for English, math, and science. Table 6 in the appendix reports the effects of ADHD medication on test scores broken up by subject.

Table 1.8: ADHD Treatment Effects on Test Scores by Gender and Subtype

	Elementary School		**Middle School**		**High School**	
	OLS	**IV**	**OLS**	**IV**	**OLS**	**IV**
Panel A. Female Combined-ADHD:						
Treatment	-0.059***	**-0.046**	-0.104***	**-0.202*** **	-0.070***	**-0.190*** **
	(0.013)	**(0.043)**	(0.015)	**(0.040)**	(0.022)	**(0.065)**
Mean	0.408		0.320		0.548	
N obs.	10,167		8,240		1,685	
R^2	0.247	0.247	0.230	0.222	0.312	0.302
Panel B. Male Combined-ADHD:						
Treatment	0.001	**-0.024**	-0.039***	**-0.060**	-0.037*	**0.019**
	(0.009)	**(0.039)**	(0.009)	**(0.037)**	(0.019)	**(0.057)**
Mean	0.402		0.291		0.489	
N obs.	22,398		17,267		2,939	
R^2	0.207	0.207	0.181	0.181	0.265	0.263
Panel C. Female PI-ADHD:						
Treatment	-0.087***	**-0.164**	-0.070***	**-0.132**	-0.114***	**-0.066**
	(0.022)	**(0.108)**	(0.022)	**(0.081)**	(0.037)	**(0.116)**
Mean	0.393		0.324		0.582	
N obs.	3,537		3,805		962	
R^2	0.377	0.374	0.267	0.265	0.383	0.382
Panel D. Male PI-ADHD:						
Treatment	-0.008	**0.178** **	-0.059***	**-0.005**	-0.006	**-0.045**
	(0.018)	**(0.083)**	(0.021)	**(0.083)**	(0.031)	**(0.132)**
Mean	0.411		0.292		0.517	
N obs.	6,122		6,187		1,351	
R^2	0.289	0.270	0.211	0.209	0.288	0.287

Notes: Combined-ADHD represents the sample of individuals diagnosed with combined inattentive and hyperactive/impulsive ADHD (Panels A. & B.). PI-ADHD represents the sample of individuals diagnosed with predominantly inattentive ADHD (Panels C. & D.). The coefficient estimates in this table can be interpreted as the effect of ADHD medication within a year of the individual's ADHD diagnosis on the probability of passing both the English and mathematics examinations. All specifications include school controls, birth year, year of diagnosis, and school year controls. We also control for the individual's grade, comorbid psychiatric conditions, if the individual is English proficient, mother's age and education at birth, family income, number of children and adults in the household, and number of patients diagnosed by the individual's diagnosing provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

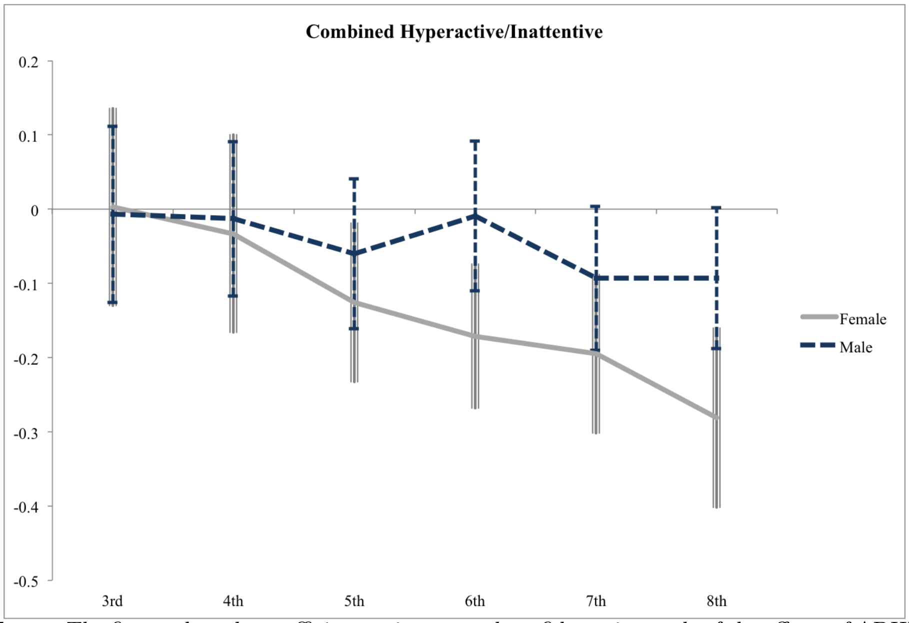
sequent grade, consistent with human capital accumulation theory. For females diagnosed with combined hyperactive/inattentive ADHD, medication treatment reduces the probability of passing both the English and mathematics examinations by 12.6 percentage points in fifth grade, 17.1 percentage points in sixth grade, 19.5 percentage points in seventh grade, and 28.1 percentage points in eighth grade. For males diagnosed with combined hyperactive/inattentive ADHD, medication treatment appears to have no effect in 3rd through 6th grade. In 7th and 8th grade ADHD medication reduces the probability of passing the English and mathematics examinations by 9.3 percentage points.

Figure 1.4 presents the effects of ADHD medication treatment for females and males diagnosed with predominantly inattentive ADHD. The findings show that there are no conclusive effects of ADHD medication on females diagnosed with predominantly inattentive ADHD, although in the majority of grades the coefficient is negative. On the other hand, we find evidence that ADHD medication has beneficial effects for male students diagnosed with predominantly inattentive ADHD in elementary school. For males with predominantly inattentive symptoms, ADHD medication increases the probability of passing both the English and mathematics examinations by 21.4 percentage points in 3rd grade, 26.8 percentage points in 4th grade, and 15.2 percentage points in 5th grade. The positive effects of ADHD medication disappear in middle school.

1.6.2.3 Grade Repetition

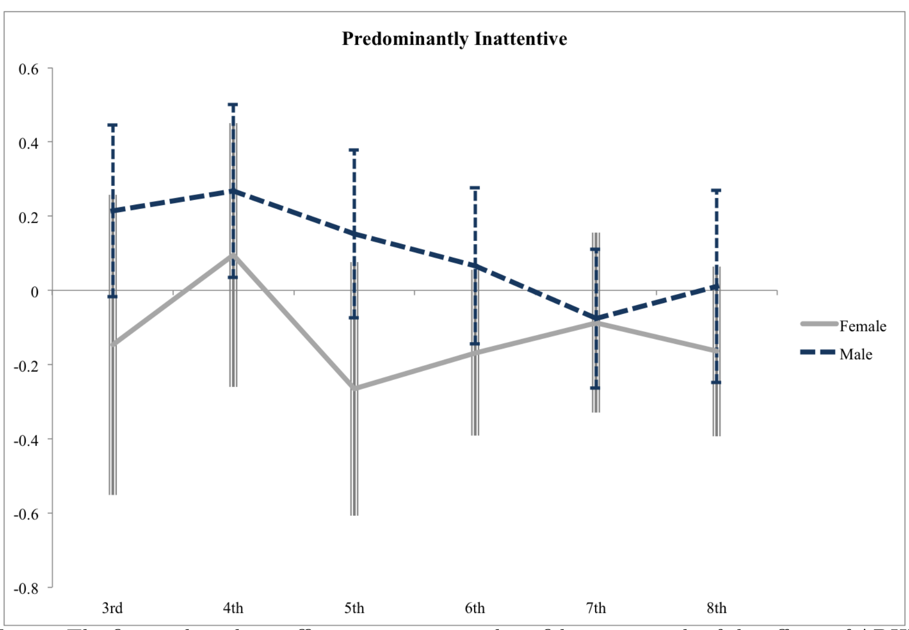
Table 1.9 presents the effects of ADHD medication on grade repetition by gender and ADHD symptoms. Considering ADHD medication has negative effects on the test scores of females diagnosed with combined hyperactive/inattentive ADHD, it is not surprising that medication increases the probability of grade repetition. If a female with combined hyperactive/inattentive ADHD takes medication, they are 2.5 percentage points more likely to repeat a grade in a given school year. For females with predominantly inattentive ADHD, we find that the coefficient on ADHD medication is positive but not statistically significant.

Figure 1.3: Effects of ADHD Medication on Test Scores over Grades



Notes: The figure plots the coefficient estimates and confidence intervals of the effects of ADHD medication within a year of the individual's ADHD diagnosis on the probability of passing both the English and mathematics examinations by grade.

Figure 1.4: Effects of ADHD Medication on Test Scores over Grades



Notes: The figure plots the coefficient estimates and confidence intervals of the effects of ADHD medication within a year of the individual's ADHD diagnosis on the probability of passing both the English and mathematics examinations by grade.

For both males diagnosed with combined hyperactive/inattentive ADHD and males diagnosed with predominantly inattentive ADHD, we find that ADHD medication increases the probability of grade repetition by 1.8 percentage points in a given year. However, the estimate is only statistically significant for the sample of males with combined hyperactive/inattentive ADHD.

Table 1.9: ADHD Treatment Effects on Grade Repetition by Gender and Subtype

	Combined-ADHD				**PI-ADHD**			
	Female		**Male**		**Female**		**Male**	
	OLS	**IV**	**OLS**	**IV**	**OLS**	**IV**	**OLS**	**IV**
Treatment	0.013***	**0.025****	0.005**	**0.018***	0.020***	**0.017**	0.000	**0.018**
	(0.004)	**(0.011)**	(0.003)	**(0.010)**	(0.006)	**(0.023)**	(0.005)	**(0.023)**
Race: Black	0.014***	0.015***	0.012***	0.013***	0.014*	0.013*	0.017***	0.017***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.007)	(0.008)	(0.006)	(0.006)
Hispanic	-0.035**	-0.032*	0.009	0.011	-0.048	-0.048	-0.044*	-0.044
	(0.018)	(0.018)	(0.014)	(0.014)	(0.034)	(0.034)	(0.027)	(0.027)
Other	0.007	0.008	0.013*	0.014**	-0.005	-0.005	0.030**	0.030**
	(0.010)	(0.010)	(0.007)	(0.007)	(0.017)	(0.017)	(0.013)	(0.013)
Num children in HH	0.005***	0.005***	0.004***	0.004***	0.001	0.001	0.001	0.001
	(0.002)	(0.002)	(0.001)	(0.001)	(0.003)	(0.003)	(0.002)	(0.002)
Mother's Educ: Less than HS	0.025***	0.024***	0.006	0.006	0.011	0.011	0.024*	0.024*
	(0.008)	(0.008)	(0.017)	(0.017)	(0.007)	(0.007)	(0.012)	(0.013)
Some HS	0.011***	0.011***	0.011	0.011	0.007**	0.007**	0.005	0.005
	(0.004)	(0.004)	(0.007)	(0.007)	(0.003)	(0.003)	(0.005)	(0.005)
Some college	-0.009**	-0.009*	-0.018**	-0.018**	-0.008**	-0.008**	-0.011	-0.010
	(0.005)	(0.005)	(0.008)	(0.008)	(0.003)	(0.003)	(0.007)	(0.007)
College degree	-0.003	-0.003	-0.033***	-0.033***	-0.007	-0.006	-0.016	-0.015
	(0.008)	(0.008)	(0.013)	(0.013)	(0.006)	(0.006)	(0.010)	(0.010)
Mental condition	0.005	0.005	0.007	0.007	0.013***	0.013***	0.013***	0.013***
	(0.003)	(0.003)	(0.006)	(0.006)	(0.003)	(0.003)	(0.005)	(0.005)
English proficient	-0.037*	-0.038*	-0.029	-0.028	-0.000	-0.000	-0.068**	-0.071**
	(0.020)	(0.020)	(0.040)	(0.041)	(0.015)	(0.015)	(0.032)	(0.032)
Mean	0.060		0.077		0.059		0.075	
N obs.	32,081		67,033		12,387		20,319	
R^2	0.218	0.218	0.220	0.220	0.301	0.301	0.270	0.269

Notes: Combined-ADHD represents the sample of individuals diagnosed with combined inattentive and hyperactive/impulsive ADHD. PI-ADHD represents the sample of individuals diagnosed with predominantly inattentive ADHD. The coefficient estimates in this table can be interpreted as the effect of ADHD medication within a year of the individual's ADHD diagnosis on the probability of repeating a grade in a given year. All specifications include school controls, birth year, year of diagnosis, and school year controls. We also control for the individual's grade, comorbid psychiatric conditions, if the individual is English proficient, mother's age and education at birth, family income, number of children and adults in the household, and number of patients diagnosed by the individual's diagnosing provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

1.7 Robustness

We perform a number of robustness checks, reported in Table 2.7. First, we test the sensitivity of our results when we control for provider specialty. In our dataset, we observe that providers report different specialties on Medicaid claims. Due to switching, choosing a provider's specialty at one time period may not be a reliable measure of the provider's true specialty. However, neglecting to control for provider specialty could violate the exclusion restriction. For example, the exclusion restriction could be violated if doctor propensity to prescribe is correlated with provider specialty and if provider specialty has a direct effect on individuals' academic performance. To address this concern, we use the provider's declared specialty at the time of the individual's ADHD diagnosis and find that the results are robust. ADHD medication has adverse effects for females diagnosed with combined-ADHD reducing the probability of passing test scores by 9.9 percentage points in middle school and 20.9 percentage points in high school. On the other hand, ADHD medication increases the probability of passing elementary test scores by 20.2 percentage points for males diagnosed with PI-ADHD.

For our primary specification, we follow Dalsgaard et al. (2014) and include providers that diagnose two or more patients a year. On average, the providers in our sample diagnose 37 patients per year with ADHD. Following discussion in Doyle (2007), Heckman (1981) and Greene et al. (2001) consider small sample sizes per group to allow for meaningful estimates, with a rule of thumb of eight observations per group. For robustness, we condition on providers diagnosing at least eight patients. For females with combined-ADHD, we find that the effects of ADHD medication on middle school and high school performance are nearly unchanged. Interestingly, when conditioning on diagnosing providers to have diagnosed at least eight patients, the positive coefficient on treatment shrinks and is no longer statistically significant for elementary male students with PI-ADHD. Furthermore, the negative coefficients on treatment become precise for combined-ADHD males' middle and high school test scores, as well as PI-ADHD females' elementary school test scores, suggesting that medication could have further adverse effects. The estimates show that males with combined-ADHD are 6.7 and 6.2 percentage points less likely to pass the middle and high school exams and females with PI-ADHD are 14.7 percentage points less likely to pass the elementary exams.

Ideally, we would like to control for special educational services that the individual may receive. If low prescribing providers are more likely to encourage parents to seek special educational services through their school, our results could be biased. Although we do not have information on special educational services, the Department of Education data include information on whether the individual has a registered learning disability. We use learning disability registered through the individual's school because in order for a student to enroll in special educational services, they must have a registered learning disability. We exclude this in our preferred specification because we are unable to observe the type of learning disability or when the individual was diagnosed with the learning disability. Our results are robust when we control for learning disabilities: females with combined-ADHD who receive treatment are 17.4 percentage points less likely to pass the middle school exams and 15.6 percentage points less likely to pass the high school exams. Elementary male students with PI-ADHD are 14.1 percentage points more likely to pass the elementary exams.

Table 1.10: Robustness

	Elementary School			Middle School			High School		
	Doc spec	**N patients**	**Learn dis**	**Doc spec**	**N patients**	**Learn dis**	**Doc spec**	**N patients**	**Learn dis**
Panel A. Female Combined-ADHD:									
Treatment	0.020	-0.070*	-0.053	-0.099**	-0.190***	-0.174***	-0.209**	-0.182**	-0.156**
	(0.053)	(0.040)	(0.036)	(0.048)	(0.035)	(0.030)	(0.097)	(0.080)	(0.068)
Mean	0.410	0.405	0.408	0.321	0.314	0.320	0.547	0.539	0.547
N obs.	9,533	7,693	10,167	7,803	6,536	8,240	1,668	1,324	1,668
Panel B. Male Combined-ADHD:									
Treatment	-0.032	-0.067*	-0.025	0.011	-0.062**	-0.053*	-0.025	-0.013	0.037
	(0.046)	(0.035)	(0.031)	(0.044)	(0.031)	(0.029)	(0.151)	(0.068)	(0.060)
Mean	0.402	0.397	0.402	0.290	0.289	0.291	0.487	0.476	0.487
N obs.	21,160	17,175	22,398	16,370	13,745	17,267	2,900	2,328	2,900
Panel C. Female PI-ADHD:									
Treatment	0.054	-0.147*	-0.112	-0.069	-0.105	-0.089	0.004	0.025	-0.009
	(0.104)	(0.084)	(0.081)	(0.097)	(0.073)	(0.066)	(0.076)	(0.134)	(0.112)
Mean	0.396	0.385	0.393	0.322	0.321	0.324	0.583	0.571	0.583
N obs.	3,183	2,266	3,537	3,474	2,627	3,805	945	653	945
Panel D. Male PI-ADHD:									
Treatment	0.202**	0.045	0.141**	-0.054	-0.087	0.023	0.099	-0.164	-0.047
	(0.096)	(0.070)	(0.061)	(0.087)	(0.056)	(0.058)	(0.193)	(0.120)	(0.121)
Mean	0.410	0.397	0.411	0.288	0.281	0.292	0.519	0.521	0.519
N obs.	5,532	4,045	6,122	5,641	4,443	6,187	1,331	919	1,331

Notes: Combined-ADHD represents the sample of individuals diagnosed with combined inattentive and hyperactive/impulsive ADHD (Panels A. & B.). PI-ADHD represents the sample of individuals diagnosed with predominantly inattentive ADHD (Panels C. & D.). The coefficient estimates in this table can be interpreted as the effect of ADHD medication within a year of the individual's ADHD diagnosis on the probability of passing both the English and mathematics examinations. All specifications include school controls, birth year, year of diagnosis, and school year controls. We also control for the individual's grade, comorbid psychiatric conditions, if the individual is English proficient, mother's age and education at birth, family income, number of children and adults in the household, and number of patients diagnosed by the individual's diagnosing provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

1.8 Discussion and Conclusions

With the rise of attention-deficit/hyperactivity disorder (ADHD) diagnoses and the evidence that children with ADHD perform worse academically, a natural question that arises is if ADHD medication improves students' academic performance. This paper analyzes the effects of ADHD medication on children and adolescents' educational outcomes using variation in physicians' prescribing rates of ADHD medication.

This study uses a unique data set of South Carolina Medicaid claims data merged with academic outcomes. The data allow us to identify the individual's ADHD subtype based on symptoms: predominantly inattentive versus combined inattentive and hyperactive/impulsive symptoms. To our knowledge, our study is the first to consider heterogenous treatment effects by gender and ADHD subtype: 1) females with combined inattentive and hyperactive/impulsive ADHD, 2) females with predominantly inattentive ADHD, 3) males with combined inattentive and hyperactive/impulsive ADHD, and 4) males with predominantly inattentive ADHD. The estimates suggest that ADHD medication has mostly adverse effects on academic performance. If treated with ADHD medication, males and females are more likely to repeat a grade. We find that ADHD medication makes females with combined inattentive and hyperactive/impulsive ADHD less likely to pass middle and high school state standardized tests.[29] The only evidence we find of ADHD medication having beneficial effects are for elementary school males diagnosed with predominantly inattentive ADHD, but these effects vanish by middle school.[30]

Our results are consistent with the Currie et al. (2014) study. Because we observe if and when an individual takes ADHD medication, a contribution of our study is that we can directly measure the effect of ADHD medication on academic measures. Further, we have more detailed education data providing us with a rich set of outcome measures and controls.

[29] Treated females with combined inattentive and hyperactive/impulsive ADHD perform worse in elementary school when we use test scores by subject. See Table 6.

[30] This result is not robust when we condition on the individual's diagnosing provider diagnosing at least 8 patients. See Table 2.7.

A limitation of our study is that we are unable to identify the mechanisms by which why ADHD medication has negative effects on academic performance. In our sample, individuals diagnosed with combined inattentive and hyperactive/impulsive ADHD take statistically higher dosages of medication which could increase the likelihood of side effects (see Table 3.2). One plausible explanation is that the side effects of ADHD medication such as depression, headaches, loss of appetite and sleep deprivation, may impede academic performance.

Hinshaw et al. (2012) studies 140 females diagnosed with ADHD and finds that they face a high risk of internalizing, and even self-harmful behavior patterns. The risk is even higher for females diagnosed with combined inattentive and hyperactive/impuslive ADHD. Barkley (2006) discusses several studies that show that children with both ADHD and anxiety or affective disturbance are more likely to show adverse responses to medication (Taylor, 1993; Voelker, Lachar & Gdowski, 1983; Pliszka, 1987). In our data we find that both females and males with combined inattentive and hyperactive/impulsive ADHD have statistically higher prevalence of comorbid psychiatric conditions. In our study we control for comorbid psychiatric conditions that the individual was diagnosed with prior to their ADHD diagnosis, but we believe more research should be devoted to looking at the effects of ADHD medication when taken simultaneously with other medications.

Although we find mostly negative affects of ADHD medication on academic performance, Chorniy and Kitashima (2015) and Dalsgaard et al. (2014) find that ADHD medication is beneficial for behavioral outcomes. Specifically, the findings of these studies suggest that ADHD medication reduces the probability of risky sexual behavior, substance abuse, and injuries and to some extent protects against criminal outcomes. Combining these findings with the findings in this study, it appears that ADHD medication may be effective in improving behavioral outcomes but harms academic performance for a subset of the population. It is worth noting that we are unable to generalize our results to the non-Medicaid population. However, the Medicaid population has relatively lower academic achievement and is at higher risk of negative health outcomes. Given the evidence of these studies, we hope future research is devoted to comparing the benefits and costs of ADHD medication.

Chapter 2

Sex, Drugs, and ADHD: The Effects of ADHD Pharmacological Treatment on Teens' Risky Behaviors (with Anna Chorniy)

2.1 Introduction

Attention-deficit/hyperactivity disorder (ADHD) is one of the common chronic mental conditions affecting children. In the U.S., 11% of children ages 4-17 (6.4 million) are estimated to have an ADHD diagnosis and almost 70% of them report taking medication for the condition (e.g. Visser et al. (2014)). However, little evidence exists on the effects of ADHD treatment on children's outcomes.

The two most recently published studies produce mixed evidence on the effects of ADHD treatment. Currie et al. (2014) find that taking stimulant medication is associated with a deterioration in academic outcomes and relationship with parents. In contrast, Dalsgaard et al. (2014) show that treatment is associated with fewer hospital visits and a reduction in the number of interactions with the police.

Our paper has three major contributions to this literature. First, we are building on our earlier work to investigate the effects of ADHD medication treatment on a seldom studied set of outcomes associated with this condition: adolescent risky behaviors and the incidence of injuries (Chorniy (2015)). The occurrence of injuries allows us to evaluate short-term effects of ADHD treatment, while substance abuse and risky sexual behavior outcomes speak for the long-term effects of medication. Second, we use Medicaid spending on treatment of these negative events to evaluate the impact of ADHD drugs on the severity of ADHD, and compare the cost of ADHD treatment with the costs of negative health events. Finally, we provide innovative supporting evidence in favor of using provider propensity to prescribe as an instrument for medical treatment. Variants of this instrument were employed in the work by Dalsgaard et al. (2014) and Duggan (2005), as discussed in Section 2.5.

We use a panel data set of South Carolina Medicaid claims paid out in 2003-2013. Our sample of diagnosed and undiagnosed children includes an average of 257,000 enrollees per year, or nearly 50% of all beneficiaries and over 25% of all SC children and teens. Children enrolled in SC Medicaid are disproportionately diagnosed with ADHD. It is consistent with the earlier literature that suggests that the probability of being diagnosed with ADHD is negatively correlated with socio-economic status (e.g. Visser et al. (2014), Froehlich et al. (2007), and Dalsgaard et al. (2014)). Between 2003 and 2011, the average incidence of ADHD in South Carolina was 12.6%.[1] However, for children and teens enrolled in Medicaid, the average rate in these years was 19.7%. Although we are unable to make a statement on the effectiveness of ADHD treatment in general population, our sample represents a large fraction of the state population, and even larger fraction of diagnosed children. Since children on Medicaid are disproportionately diagnosed with ADHD and their incentives are distorted in the absence of a drug price tag, this population is arguably more appropriate for this study from a policy perspective.

Nearly 80% of SC Medicaid children and teens who are diagnosed with ADHD are taking medication for their condition. Consistent with the national trend, our data also show a steep increase in Medicaid spending on ADHD prescription drugs. Between 2003 and 2013, it rose by 296% in 2013 dollars. This increase in spending is a consequence of both the increase in the number of prescriptions filled and the prices of the drugs. The number

[1]CDC. "Trends in the Parent-Report of Health Care Provider-Diagnosed and Medicated ADHD: United States, 2003-2011."

of patients who take ADHD medications rose by 68% and the number of prescriptions per person went up by 18% suggesting that the overall trend is driven by the extensive margin.[2]

Our results suggest that pharmacological treatment reduces the probability of every negative health and behavioral outcome that we identified in the data. If a patient is treated with ADHD medication the probability of contracting an STD decreases by 3.6 percentage points (5.8 percentage points if we include STD screening), having a substance abuse disorder decreases by 7.3 percentage points, becoming injured by 2.3 percentage points each year and annual injury spending decreases by $88.4, or 0.054 of a standard deviation.[3] Finally, the probability of teenage pregnancy decreases by 2.3 percentage points, though the effect is not statistically significant.

2.2 Background and previous research

2.2.1 ADHD and ADHD-associated negative health outcomes

The American Psychiatric Association defines ADHD as a neurodevelopmental condition present if either six or more of the inattention symptoms or six or more hyperactivity-impulsivity symptoms "have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level."[4] Inattentive symptoms include difficulty holding attention on tasks, following instructions, and distractibility among others. Hyperactivity and impulsivity criteria include excessive talking, difficulty waiting, and fidgeting. Causes of ADHD are not fully understood but genes are recognized as a major determinant of the condition.

ADHD may adversely impact major life activities from childhood to adulthood.

[2]There is some evidence of ADHD being increasingly misdiagnosed (e.g. Evans et al. (2010), Elder (2010), Schwandt and Wuppermann (2015), and Morrill (2016) among others). This question is out of scope of this paper. If there are false positive cases of ADHD diagnosis in our sample, our estimates of the effect of ADHD treatment on negative health outcomes outcomes can be interpreted as a lower bound of the actual effect of medication.

[3]In 2013 dollars.

[4]The American Psychiatric Association publishes the Diagnostic and Statistical Manual of Mental Disorders (DSM), where it sets criteria for the classification of mental disorders. It is the standard classification of mental disorders used by mental health professionals in the United States. The most current version is DSM-5 published in May 2013, a revision of DSM-IV-TR that came out in 2000.

Earlier studies have found that untreated ADHD could have severe consequences and be distressing not only for children who suffer from the condition but also for their families (Kvist et al. (2013), Fletcher and Wolfe (2009)), siblings (Breining (2014)), friends, peers (Aizer (2008)), and teachers (Barkley (2006)). Children with ADHD tend to have problems with self-control and discount the future more heavily than their unaffected peers. This makes them more injury-prone[5] and more likely to engage in risky behaviors such as: dangerous driving,[6] substance use and abuse,[7] and risky sexual behaviors.[8] Children growing up with ADHD were found to be more likely to experience teen pregnancy, sexually transmitted diseases (STDs), depression, and personality disorders as adults.

These health and behavioral outcomes can be explained in the theoretical framework of investment in child well-being. Every child is born with a multidimensional endowment of abilities. They include cognitive (e.g. IQ, memory) and noncognitive skills (e.g. self-control, patience, and time preference)(Conti and Heckman (2014)). Due to their genetic condition, children who suffer from ADHD have a relatively low initial stock of noncognitive skills. The literature on child development indicates that gaps in abilities that form early in life persist into adulthood and can explain a large array of differentials in adult outcomes. Conti

[5]Besides having more frequent injuries, these children also tend to have more severe injuries than their peers (Barkley (2006), Swensen et al. (2004), and Marcus et al. (2008)). In a recent study, Dalsgaard et al. (2015) show that children with ADHD have a higher risk of injuries, but it declines in patients treated with stimulant medications.

[6]One of the strongest findings in the medical literature is that ADHD adolescents are more likely be involved in a car accident and they are more often at fault in such accidents (Barkley (2006), Weiss and Hechtman (1993)).

[7]Looby (2008) provides a review of major studies on the association of ADHD and substance use and abuse, including alcohol, tobacco, and drugs. Some of them find that teens with ADHD are on average more likely than individuals without ADHD to smoke, use and abuse alcohol and drugs, and develop health problems related to these activities. However, others conclude that there are additional related conditions that contribute to the likelihood of these negative health outcomes, e.g. conduct disorder symptoms and association with deviant peers. Despite a disagreement on the relationship between ADHD and substance use, Looby (2008) review suggests that ADHD treatment reduces the risk of substance use disorders in children with ADHD. Using a meta-analysis, Wilens et al. (2003) also find that stimulant medications reduce the risk for subsequent drug and alcohol use disorders.

[8]Adolescents with untreated ADHD have difficulty controlling their impulses and planning ahead. These teens also tend to struggle with low self-esteem and for that reason, teenage girls often seek affirmation of boys through sexual attention (Arnold (1996)). Adolescent girls' symptoms of ADHD often worsen due to the hormonal changes at puberty (Resnick (2005)). Their condition makes them more likely to become sexually active earlier than their peers, have more partners on average, and use birth control inconsistently (Kessler et al. (1997), Payne (2014)). This association is also found in a more recent study by Sarver et al. (2014).

and Heckman (2014) provide an extensive review of the empirical evidence on the effects of investment in the two dimensions of child human capital, cognitive and noncognitive skills, on educational attainment, asocial and risky behaviors, and health. Heckman et al. (2006) find that both cognitive and noncognitive abilities affect wages, schooling, work experience, occupational choice, and participation in a range of adolescent risky behaviors. These results have important policy implications, but most interventions do not directly target children's noncognitive abilities. The Perry Preschool experiment may be an exception; it did not result in IQ improvements but instead had a beneficial impact on many child outcomes. Heckman et al. (2006) argue that these beneficial impacts were achieved by altering social skills.

In this paper, we focus on a variety of negative health outcomes associated with ADHD: injuries, substance use, and risky sexual behavior. Injuries is the most common outcome that affected 80% of children in our sample; it is relevant for children at all ages and the average age is around the mean age of ADHD diagnosis (9 years old). Risky sexual behavior and substance abuse outcomes are relevant for older children, with the average age being 14-16 years old, or 6-8 years after most children are diagnosed with ADHD. In other words, injury events allow us to evaluate short-term effects of ADHD treatment, while the risky behavior related events speak for long-term treatment effects.

2.2.2 Prior Studies

An existing body of medical literature suggests that ADHD medication has positive impacts on mitigating core symptoms of ADHD, yet little is known about the effects of treatment on health, behavioral, and educational outcomes, particularly in the long run. One of the major attempts to estimate the long-term effects of ADHD treatment in a clinical setting was funded by the U.S. National Institute of Mental Health in the early 1990s. The Multimodal Treatment of Attention Deficit Hyperactivity Disorder (MTA) randomly assigned 579 ADHD-diagnosed children age 7-9.9 years old to 14 months of treatment management. The study finds that medication treatment alone and medication treatment combined with behavioral therapy reduces inattention and hyperactivity, the core symptoms of ADHD. However, there was little or no difference in academic performance, social skills and parent-child relationships. An important limitation of the study is that nearly 70% of individuals assigned to the control group also received medication. Molina et al. (2009) investigates the effects for these randomized treatment groups 6-8 years following intervention. They find that the groups do not differ significantly on any repeated measures or new measures of outcomes: contacts with the police and arrests, delinquent behavior, social skills and academic performance.

Currie et al. (2014) take advantage of a policy change in Quebec which expanded insurance coverage for prescription medications to estimate the effect of ADHD treatment on emotional functioning and academic outcomes. Using data from the 1994-2008 National Longitudinal Survey of Canadian Youth, they find that stimulant medication treatment is associated with a decrease in academic outcomes such as grade repetition, math scores, and the probability of having any post-secondary education for girls, a deterioration in relationship with parents, and an increase in the probability of depression.

Dalsgaard et al. (2014) exploit the idiosyncratic differences in physician preferences to prescribe pharmacological treatment to analyze the effects of ADHD treatment on hospital visits and criminal behavior. Consistent with Duggan (2005), they find that prescribing practices vary significantly across medical care providers. This implies that two children with identical symptoms and characteristics have a different probability of being diagnosed and treated with medications depending on their physician's preferences. Using Danish registers data and provider probability to prescribe as an instrument, Dalsgaard et al. (2014) find that treatment receipt is associated with fewer hospital visits and fewer police interactions.

In a recent study, using the same data these authors and a number of co-authors estimate odds ratios for injuries, mean change in prevalence rates, and ER visits before and after the treatment with stimulant medication (Dalsgaard et al. (2015)). They find that children with ADHD have a higher risk of injuries than a non-ADHD group, but it declines in patients treated with stimulant medication.

We contribute to the existing literature in three ways. First, we look at a seldom studied set of ADHD-related negative health outcomes: teenage pregnancies, incidence of STDs, substance abuse disorders, and injuries. To our knowledge, this paper and its dynamic model companion (Chorniy (2015)) are the first to directly study the effects of ADHD treatment on these outcomes in health economics literature. Our general conclusions on the effect of treatment on injuries are consistent with the medical literature (Dalsgaard et al. (2015)); but we are not aware of any comparable studies on the other outcomes.

Second, we take advantage of Medicaid spending reported in the data to estimate the impact of ADHD medication on the severity of injuries, STDs, and substance abuse disorders. Medical treatment may be effective in reducing the severity of negative health outcomes even if the likelihood of having one is unchanged. Medicaid expenditures are also important from the policy perspective. In South Carolina, out-of-pocket costs for Medicaid enrollees under 19 years old are zero or negligible. This distorts the patients' incentives and puts the burden of cost-benefit analysis on policymakers. Medicaid investment in ADHD treatment might be balanced via a reduction in its spending on the ADHD-associated events. We briefly examine this question in the current work and leave the detailed study to future research.

Finally, we provide innovative supporting evidence in favor of using provider propensity to prescribe as an instrument for medical treatment. Its variants were employed in the work by Dalsgaard et al. (2014) and Duggan (2005). Our data allow us to construct a more precise measure of provider preferences and test whether there is evidence of the instrument being correlated with provider quality and whether there is evidence of provider shopping. For robustness, we also provide comparative results across a variety of instruments and treatment definitions.

2.3 Data

We use a large panel data set of South Carolina Medicaid claims that spans 11 years from 2003 to 2013. It includes 145,264 children and teenagers who had at least one ADHD-related claim between 3 and 18 years old during this time period. This sample makes up approximately 20% of the child population in the state.

Our data include basic demographic information collected to determine Medicaid eligibility and a complete set of health services utilization records for all individuals: hospital, outpatient, and pharmacy claims.[9] It is supplemented by several variables from the enrollees' birth certificates including mother's age, race, and education. Following earlier research work that used Medicaid or other administrative claims data (e.g. Frank et al. (2004)), we compile a set of ICD-9 diagnosis codes[10] and CPT procedure codes[11] to identify individuals who have ADHD, cases of pregnancy, STDs, substance use and abuse disorders,[12] and injuries[13] from the insurance claims data. Administrative data are not well-suited for distinguishing two consecutive independent events of the same kind from continuous care for the same event. For this reason, we focus on the first occurrence of each negative health outcome: teenage pregnancy, STD contraction, STD screening, and substance use and abuse disorders. While we use the first observed negative health outcome event to identify the incidence of negative health outcomes, we track all Medicaid spending related to these events across time.[14]

[9] Medicaid has two components: traditional fee-for-service (FFS) and services provided through managed care organizations (MCO). Due to the differences in reporting requirements, the complete information on all services provided to a patient are only available for those enrolled in the FFS plan. However, mental health is one of the "carved-out" conditions that is covered by the FFS component even if an individual is enrolled into a managed care plan. We use all available claims and when possible, perform robustness checks by excluding MCO enrollees.

[10] The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes are used by Medicaid for reporting purposes in the years covered by our sample. A hospital claim may have up to 9 diagnosis codes and an outpatient claim may have up to 4 codes.

[11] The Current Procedural Terminology (CPT) codes are used to indicate services provided to a patient. A hospital claim may have up to 100 procedure codes and an outpatient claim may have up to 8 codes.

[12] For substance use and abuse disorders we use a methodology developed in Bouchery et al. (2012).

[13] The ICD-9 codes for injuries were borrowed from Marcus et al. (2008).

[14] We disregard any out-of-pocket expenditures in this study. In 2013, most eligible individuals faced a small copay per doctor visit ($3.30), per prescription ($3.40 for adults over 19 years old and zero otherwise), and per hospital stay ($25).

We use pharmacy claims to extract information on ADHD prescription medications that were filled by a patient. Each record has a dispense date, National Drug code (NDC),[15] quantity purchased, dispense fee, and the amount paid by Medicaid. We use our previous work (Chorniy (2015)) to identify drugs that are typically prescribed to patients with ADHD and to construct our instrumental variable (Section 2.4).

To estimate our model, we put a number of restrictions on the original data set. First, we select individuals who are consistently enrolled for Medicaid for a year or more for us to be able to estimate the effect of treatment. For lapses in enrollment that last under three months, we assume that patients are enrolled but receive no medical treatment.[16] For inconsistent eligibility periods that result in longer lapses in coverage (48% of the enrollees experience at least one such lapse), we only keep medical history prior to the lapse. These criteria leave us with 107,062 Medicaid enrollees.

Second, due to the fact that our instrument is based on the event of the initial ADHD diagnosis, we exclude individuals for whom we are unable to identify this event. Following earlier literature (e.g. Crawford and Shum (2005)), we only look at patients who had their first ADHD-related visit within 180 days from their first appearance in the sample and patients who fill a prescription prior to their first observed ADHD-related provider visit. This restriction excludes 29,974 additional individuals from the sample. Additionally, a patient had to be diagnosed between 3 and 18 years old and be in the sample for at least one full year since the event of the first ADHD diagnosis to be included in the analysis; 62,643 patients satisfied this criteria. Our final sample has 58,685 individuals after excluding ADHD children with missing basic demographic information and children for whom we were unable to calculate provider propensity to prescribe.[17]

Table 3.2 shows summary statistics on individual, mother, and home environment

[15] NDC is an 11-digit classification issued by the Food and Drug Administration (FDA) for all the approved drugs.

[16] Once eligibility for Medicaid is established, the health insurance coverage is available for an enrollee for a 12-month period (unless the enrollee becomes ineligible during this time), after which the eligibility needs to be reconfirmed. An eligible individual who received services prior to the actual enrollment can be covered retroactively for up to two months prior to the month when eligibility was established.

[17] We are unable to calculate a provider propensity to prescribe for providers who diagnose less than 2 patients with ADHD in a year.

characteristics. Boys comprise 66% of the sample, similar to the proportion of boys (69%) reported by the U.S. National Survey of Children's Health in 2011 (Visser et al. (2014)). Whites and Blacks are represented nearly equally, due to the relatively higher share of Black on Medicaid. On average, children are first diagnosed with ADHD at 8 years old, and half of them are diagnosed by age of 7. Given that the population we are looking at is slightly older, this is generally consistent with the nationwide estimates. Among children age 4-17 years whose parents reported "mild" ADHD symptoms the median age of diagnosis is 7.0 years old, 6.1 years for those with "moderate" symptoms, and 4.4 years for "severe" cases of ADHD (Visser et al. (2014)).

The families predominantly consist of a single adult and two children. Their reported net monthly income is $574 on average. The majority of mothers in the sample have at least some high-school education (37%) or a high school diploma (40%). Data on mother's characteristics comes from the in-state birth certificates (matched to 72% of children in our sample).

In addition to the entire cohort of children on Medicaid who are diagnosed with ADHD in SC between 2003-2013, we have a supplemental random sample of children on Medicaid who were never diagnosed with ADHD.[18] We use this sample to test the validity of our identification strategy (see Section 2.5). Summary statistics for this group of children are shown in the appendix (Table 17 and Table 18).

Table 2.2 reports summary statistics on ADHD medical treatment and ADHD-related negative health outcomes that we observe in the sample. Nearly all children diagnosed with ADHD have attention-deficit disorder with hyperactivity (ICD-9: 314.01) as opposed to disorder without hyperactivity (ICD-9: 314.00). In our primary specification, we define pharmacological treatment as one or more prescriptions filled within a year of the individual's ADHD diagnosis (72% of patients). We also introduce two alternative definitions of treatment and results are reported in Section 2.10. We define treatment if we observe an individual ever filling a prescription after their ADHD diagnosis (79% of patients), and

[18] It includes eligibility information, hospital, and outpatient claims for the undiagnosed children under 19 years old with higher weights assigned to relevant birth cohorts.

following Dalsgaard et al. (2014) we define treatment as a period of at least six months on medication in a given year (52% of patients).

On average, we observe every Medicaid enrollee for eight years. During this time, 1,811 girls become pregnant before age 19; 3,288 teens contract an STD and an additional 2,184 are tested for an STD condition. For 5,864 teens we observe at least one claim that indicates a substance abuse disorder. The most frequent outcome that we observe yearly are injuries. Of all ADHD-diagnosed children and teens, 80% have at least one injury while in the sample.

In order to take into account the severity of negative health events, we calculate the total Medicaid spending using the respective claims. The average annual cost of treatment for an STD condition is $400 ($354 per patient if we include all patients who were screened for an STD). The annual cost of a substance abuse condition, including spending on prescribed medications is $1,499 per patient. Finally, the average cost of injuries per person per year is $704. These expenditures vary widely across patients, costing Medicaid thousands of dollars in the upper tail of the distribution.[19]

[19] All spending amounts are adjusted to 2013 dollars.

Table 2.1: Summary Statistics: Individual and Family Characteristics

	N obs.	**Mean**	**Median**	**SD**	**Min**	**Max**
Individual characteristics						
Age 1st in sample	58,685	4.12	3.00	4.04	0	18
Age at 1st ADHD diagnosis	58,685	7.98	7.00	3.46	3	18
Male	58,685	0.66			0	1
Race: White	58,685	0.47			0	1
Black	58,685	0.43			0	1
Hispanic	58,685	0.02			0	1
Family & home environment						
Monthly family net income	58,685	573.94	408.80	584.93	0	5,189
Number of adults	58,685	1.03	1.00	0.59	0	3
Number of children	58,685	1.91	2.00	0.96	0	6
Ever in foster care	58,685	0.09			0	1
Ever had disability	58,685	0.15			0	1
Mother's characteristics						
Age when gave birth	42,488	23.41	22.00	5.47	11	48
Educ: Less than HS	42,488	0.05			0	1
Some HS	42,488	0.37			0	1
HS diploma	42,488	0.40			0	1
Some college	42,488	0.13			0	1
College degree or higher	42,488	0.05			0	1

Notes: The sample includes every SC Medicaid enrollee who was diagnosed with ADHD between 3 and 18 years old in 2003-2013 and who was eligible for Medicaid for at least one year after this event. Family characteristics are averaged per patient/eligibility year. Foster care and disability rates are calculated based on Medicaid enrollment categories. Mother characteristics are reported based on in-state birth certificate information matched to Medicaid records. They are available only for a subsample of the 42,488 patients. Mother's age and educational attainment are recorded at the time of the child's birth. "HS" stands for high school education level.

Table 2.2: Summary Statistics: Medical Treatment and Negative Health Outcomes

	N obs.	Mean	Median	SD	Min	Max
Medical diagnosis & treatment						
1st diagnosis: ADD w/ hyperactivity	58,685	0.74			0	1
ADD w/o hyperactivity	58,685	0.24			0	1
1+ Rx filled within a year (1st diag)	58,685	0.72			0	1
1+ Rx filled (ever)	58,685	0.79			0	1
6+ Rx filled within a year (ever)	58,685	0.52			0	1
Annual cost of ADHD visit	58,685	586.75	152.10	1819.20	1	151,980
Annual cost of ADHD Rx	46,355	419.33	265.38	466.81	1	7,897
Years in sample	58,685	7.94	8.00	2.73	1	11
Outcome: Risky sexual behavior						
1. Teen Pregnancy						
Age at 1st pregnancy	1,811	16.67	17.00	1.75	11	19
Race: White	1,811	0.53			0	1
Black	1,811	0.43			0	1
2. STD						
Age at 1st STD	3,288	14.46	14.00	2.49	11	19
Age at 1st STD (incl. screening)	5,472	14.80	15.00	2.33	11	19
Male	3,288	0.42			0	1
Race: White	3,288	0.57			0	1
Black	3,288	0.35			0	1
Annual cost of STD	3,288	399.84	152.32	1129.51	4	19,728
Annual cost of STD+test	5,472	353.88	181.80	777.86	2	19,728
Outcome: Substance Abuse						
Age at 1st substance abuse	5,864	15.12	15.00	2.11	11	19
Male	5,864	0.64			0	1
Race: White	5,864	0.51			0	1
Black	5,864	0.42			0	1
Annual cost of substance abuse	5,864	1498.32	430.45	3640.24	1	113,834
Outcome: Injuries						
Ever injured	58,685	0.80			0	1
Age at injury	46,730	9.07	8.50	3.72	3	19
Male	46,730	0.67			0	1
Race: White	46,730	0.50			0	1
Black	46,730	0.40			0	1
N of injury claims	58,685	0.37	0.27	0.44	0	12
Annual cost of injuries	46,730	704.37	247.10	4072.36	2	501,616

Notes: The sample includes every SC Medicaid enrollee who was diagnosed with ADHD between 3 and 18 years old in 2003-2013 and who was eligible for Medicaid at least one year after this event. Alternative treatment definitions are used for the robustness checks in Section 2.10. Annual cost of treatment and negative health outcomes are given in 2013 dollars per patient/year conditional on treatment or the occurrence of a negative health outcome. They are based on the Medicaid reimbursement payouts. The out-of-pocket patient costs are nearly zero for the population in our sample.

2.4 Empirical Model

2.4.1 Lifetime Effects of ADHD Treatment

We use a linear probability model to estimate the effects of ADHD medical treatment on the incidence of adverse health and behavioral outcomes in adolescents who are diagnosed with the condition. In this experiment, we compare the outcomes of treated and not treated children with ADHD. We model outcomes as shown in Equation 2.1.

$$Y_i = X_i\beta + \alpha_i Treatment_i + \gamma_1 County_i + \gamma_2 Year_i + \varepsilon_i, \tag{2.1}$$

where Y represents one of the negative health outcomes that are common for individuals diagnosed with ADHD, i: STD contraction and STD screening, substance use and abuse, and teenage pregnancy. X is a vector of covariates that includes observed individual characteristics (race, gender, birth year), net monthly family income at the first ADHD diagnosis, patient age, and duration of enrollment.[20] We also control for the location (county of patient's residence at diagnosis) and the year of diagnosis. We exclude all individuals, treated or untreated, who have experienced an adverse outcome (STD, STD test, substance abuse, or pregnancy) prior to, or in the same year of, their ADHD diagnosis and estimate the model using post-diagnosis medical history to assure that the adverse events do not determine the instrument. Note that an advantage of this strategy over the specification where we would be looking at the occurrence of adverse events at a given age (e.g., at age 14), is that we include patients who were diagnosed later in life, conditional on not experiencing adverse events prior to the first diagnosis. This is particularly important for our long-term outcomes that are relevant during patient teen years.

For STD, STD screening, substance abuse, and teenage pregnancy outcomes we utilize a subsample of relevant birth cohorts of SC Medicaid enrollees. They are individuals born between 1987 and 1996, whose teen years overlap with our sample period and who are enrolled in Medicaid for at least one year during this time. *Treatment* takes a value of

[20] The length of the time period the individual was enrolled in Medicaid between 2003 and 2013.

one if the individual fills at least one ADHD prescription within the year of their ADHD diagnosis, as described in Section 2.3.

The parameter of interest in this equation is α. In the linear probability model framework, it can be interpreted as the average impact of being treated within the year of the individual's ADHD diagnosis on the likelihood of negative health outcomes in adolescence.

Equation 2.1 can be rewritten to reflect two potential sources of bias:

$$Y_i = X_i\beta + \bar{\alpha}Treatment_i + Treatment_i(\alpha_i - \bar{\alpha}) + \gamma_1 County_i + \gamma_2 Year_i + \varepsilon_i \tag{2.2}$$

First, if $Treatment$ is correlated with ε, unobserved factors that make some individuals more likely to receive treatment also influence their health and behavioral outcomes. For example, relatively more caring parents might be more likely to pursue medical treatment for their child. These parents are also more likely to take measures to reduce the probability of negative health outcomes associated with ADHD. In this case, our results might be biased towards finding that ADHD treatment reduces the probability of negative health outcomes. On the contrary, if, perhaps, children with the most severe ADHD symptoms are the ones to seek treatment and are also relatively more likely to experience negative health outcomes, the effect of medication treatment would be biased towards zero.

Second, $Treatment$ might be correlated with α if individuals select treatment based on expected gains. In this case, the child's outcomes may determine treatment receipt.

2.4.2 Identification

Following Dalsgaard et al. (2014) and Duggan (2005), we instrument for individual treatment with provider propensity to prescribe. If two equally sick patients have a different prescription outcome because they saw physicians with a respectively high or low propensity to prescribe, it provides exogenous variation necessary to evaluate the causal effect of treatment.

$$\text{PP}_{dit} = \frac{\text{N patients treated}_{dt} - 1 * (\text{Treated}_{dit} = 1)}{\text{N patients}_{dt} - 1} \tag{2.3}$$

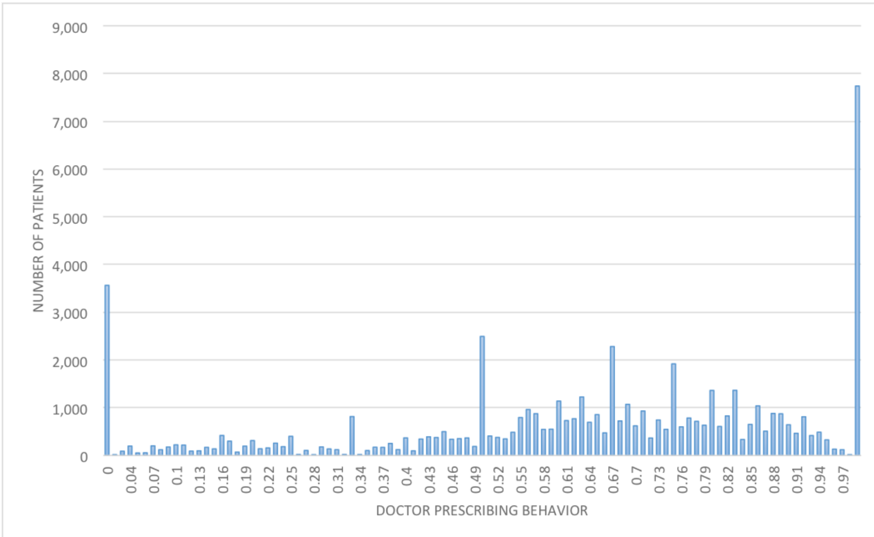
We define provider d's propensity to prescribe (PP) medication to an individual i in year t as the share of all his/her patients' treatment outcomes in a given year (Equation 2.3). The outcome of the focal individual is excluded in order to reduce potential endogeneity concerns since the patient's characteristics are not a part of the provider propensity to prescribe measure. To be included in our analysis, we require the provider to diagnose two or more patients per year. In our data, a provider diagnoses 7 patients per year, on average; the median is 3 patients, conditional on being included in our sample. This skewed distribution is consistent with what is typically found in the health economics literature. Our main estimation results are robust to only considering providers who diagnosed more than 3 or more than 7 patients, respectively (available upon request).

Since we only observe filled prescriptions, our calculated provider's propensity to prescribe a drug to a patient with ADHD includes both the probability that he/she writes a prescription and the probability that the patient fills the prescription (Dalsgaard et al. (2014)). Both events, conditional on the provider's engagement with the patient, are relevant provider variation.[21]

Stockl et al. (2002) survey a 1,000 randomly selected physicians who prescribe stimulant medication to patients between December 2001 and May 2002. They document considerable variation in physicians' perception of the severity of ADHD medication side effects and their concern about the medication being used for purposes other than patient's medical needs. Similar to earlier research, we find that patients face significant variation in the probability of receiving a prescription (Figure 2.1).

[21]In the earlier literature, physician prescribing practices were found to vary with the reimbursement mechanism (Dickstein (2014)) and their individual preferences (Hellerstein (1998)).

Figure 2.1: Distribution of Provider Propensity to Prescribe



Notes: The figure shows the distribution of the probability that a patient receives a prescription from a particular physician in the year she was diagnosed based on the sample of 58,685 ADHD-diagnosed patients enrolled in SC Medicaid in 2003-2013. Provider propensity to prescribe varies from zero to one.

We, thus, use provider propensity to prescribe to instrument for the treatment receipt. The first stage is given by Equation 2.4:

$$Treatment_i = \delta PP_i + X_i\theta + \nu_i, \tag{2.4}$$

where PP is a patient-specific probability to receive a prescription from the diagnosing provider; X is a vector of controls from the Equation 2.1. The second stage is given by Equation 2.5:

$$Y_i = \alpha \widehat{Treatment}_i + X_i\beta + \varepsilon_i, \tag{2.5}$$

where $\widehat{Treatment}$ is the predicted treatment from Equation 2.4, and β is the marginal treatment effects of ADHD medication on adolescent's negative health outcomes.

To illustrate our identification strategy, consider two types of doctors: doctors with a high propensity to prescribe and doctors with a low propensity to prescribe. For very severe cases of ADHD, both doctors would recommend medication treatment and thus the effect of treatment on children's negative health outcomes cannot be identified. Alternatively, for children with few to no ADHD symptoms, both doctors would not recommend medication treatment. The comparison of outcomes across doctors' prescribing behaviors would thus focus on the variation of treatment among marginal cases. Equation 2.5 will produce consistent estimates provided that PP influences treatment and is uncorrelated with the error term, ε (see Section 2.5 for supporting evidence). Note that we also explicitly assume monotonicity of our instrument. If a patient is prescribed medication by a provider with a low propensity to prescribe, she must also be prescribed treatment by a provider with a high propensity to prescribe.

2.4.3 Yearly Effects of ADHD Treatment

Another way to look at the effects of ADHD treatment on negative health outcomes is by taking advantage of the panel feature of our data set. It allows us to control for patient's age, year-specific trends, and other observed time-varying factors that could have an effect on individual health outcomes. For example, age-specific risks of outcomes such as pregnancy, STD contraction, and substance abuse are in the fixed effects, which reduces the variance in the error term.

Moreover, this approach requires fewer assumptions about data. While in the "lifetime" analysis (cross-section setup) it is assumed that an individual had no adverse outcomes if she is not actively enrolled in Medicaid and has no claims,[22] per-year effects are identified strictly off the observed continuous Medicaid enrollment period. Due to the nature of administrative records, we are unable to reliably tell apart two separate negative health events of the same type. Thus, we do not track individuals past their first adverse outcome (except for the injuries). The empirical model is specified in the Equation 2.6 below.

$$Y_{it} = \alpha \widehat{Treatment}_i + X_i\beta + Z_{it}\gamma_1 + \gamma_2 County_{it} + \gamma_3 Year_{it} + \gamma_4 Year \times County_{it} + \varepsilon_{it}, \quad (2.6)$$

[22] See discussion in Section 2.5.2.4

where Y is a negative health outcome for an ADHD patient i in year t; $\widehat{Treatment}$ represents medical treatment instrumented with provider propensity to prescribe. As in the "lifetime" effects analysis, treatment is defined as "treated within a year of the individual's ADHD diagnosis" and the instrument itself does not have a time subscript. X is a vector of controls that includes individual characteristics that do not vary with time: race, sex, and birth cohort; Z includes time-varying controls: age, monthly family income; $Year$ represents year controls; $County$ stands for the county of residence;[23] $Year \times County$ are county/year interactions, and ε is a stochastic error term. Note that we exclude all individuals, treated and untreated, who have experienced an adverse outcome (STD, STD test, substance abuse, or pregnancy) prior to their ADHD diagnosis and we estimate the model using post-ADHD diagnosis medical history. For STD, STD screening, substance abuse, and teenage pregnancy outcomes we utilize a subsample of individuals born between 1987 and 1996, whose teen years overlap with the time period of our data set.

For the outcomes related to teenagers' risky behavior, the parameter of interest, α can be interpreted as the average effect of receiving treatment within a year of the individual's ADHD diagnosis on the first incidence of a negative health outcome. For the incidence and number of injuries, the coefficient on treatment can be interpreted as the average annual effect of receiving treatment within a year of the individual's ADHD diagnosis.

Ideally, one would like to know how treatment length or being diagnosed at a certain age can change treatment effects. Since we are unable to address the endogeneity issues that arise with the use of treatment length or age of diagnosis with our instrument, it is left for the future research to find an identification strategy that would shed light on these questions.

[23] For robustness, we use county unemployment rate, county income, and county population density instead of county controls and our findings hold.

2.5 IV Validity

2.5.1 Condition 1: First Stage Results

The first stage results for the entire sample (Table 2.3) and the outcome-specific results (Table 2.6) show that the relationship between the provider propensity to prescribe ADHD medication and the probability that the child fills a prescription within in a year of their ADHD diagnosis is positive. It holds when we include a number of controls, such as family and individual characteristics, mother's age and education level, county, and birth cohort fixed effects. The estimated magnitude of the coefficient in the specification that includes all the controls and fixed effects (Table 2.3, column 3) suggests that a 10 percentage point increase in the provider propensity to prescribe is associated with a 4.5 percentage points increase in the probability of treatment receipt.

This relationship does not seem to be driven by the "extreme" values of provider propensity to prescribe. When we exclude all providers who either never prescribe ADHD medication or prescribe drugs to every child they diagnose, the first-stage result becomes stronger.

2.5.2 Condition 2: Exclusion Restriction

In order for our instrumental variable approach to be valid, the exclusion restriction must hold. In our data, providers are not randomly assigned to patients but it is a necessary condition for a provider propensity to prescribe to affect patient outcomes only through pharmacological treatment.

In this section, we devise a number of tests that could be indicative of a violation of this assumption. There are three potential threats that we address and provide suggestive evidence in favor of the validity of doctor propensity to prescribe. First, provider prescribing preferences might be correlated with the provider quality and thus, would affect patient outcomes directly rather than through treatment receipt. Second, both our instrument and patient outcomes may be correlated with unobserved individual, family, and other

Table 2.3: Results: First Stage

	(1)	(2)	(3)	(4)
Propensity to prescribe	**0.505**[a]	**0.458**[a]	**0.454**[a]	**0.549**[a]
	(0.006)	**(0.006)**	**(0.007)**	**(0.011)**
Male		0.043[a]	0.047[a]	0.047[a]
		(0.004)	(0.004)	(0.005)
Race: Black		-0.056[a]	-0.055[a]	-0.057[a]
		(0.004)	(0.005)	(0.005)
Hispanic		-0.126[a]	-0.176[a]	-0.184[a]
		(0.011)	(0.016)	(0.018)
Other		-0.057[a]	-0.071[a]	-0.077[a]
		(0.008)	(0.010)	(0.011)
Family net income		0.005[b]	0.006[c]	0.005
		(0.002)	(0.003)	(0.003)
Number of adults		-0.018	0.011	-0.001
		(0.003)	(0.004)	(0.004)
Number of children		0.001	0.001	0.002
		(0.002)	(0.002)	(0.002)
Cohort & County F.E.	N	Y	Y	Y
Mother characteristics	N	N	Y	Y
Propensity to prescribe $\in (0,1)$	N	N	N	Y
R-squared	0.099	0.129	0.116	0.104
N obs.	58,685	58,685	42,693	34,507

Notes: The dependent variable in every specification is the binary prescription outcome for a patient. It equals one if the patient had an ADHD prescription within a year of their ADHD diagnosis while on Medicaid and zero otherwise. Controls that are not shown include individual's county of residence, foster care, and disability status at the time of the diagnosis. Mother characteristics include mother's age when she gave birth and educational attainment. Family net income is measured in ten thousands of dollars; the coefficients on the number of adults are scaled up by 10 in order to show the magnitude of the effect. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with *a*, *b*, and *c* respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

characteristics. Finally, there might be a sample selection problem if the individual's length of enrollment in Medicaid is related to the provider propensity to prescribe. Although these tests do not ensure that the exclusion restriction is satisfied, they provide us with more confidence in that our instrument is valid.

2.5.2.1 Provider quality and propensity to prescribe

Physician quality, experience, and training have an impact on patient outcomes. If the propensity to prescribe medication reflects physician quality, it may confound our results. For example, it could be the case that providers who prescribe medication to every single one of their patients do not properly evaluate patient symptoms and/or determine a treatment strategy that would suit each particular case. In other words, if high prescribing providers are those of lower quality, we would expect to find that treatment has unfavorable effects on health outcomes.

To address this concern we devise a placebo test. If provider quality is not related to his or her propensity to prescribe, we should see no relationship between the instrument and health outcomes of children who were never diagnosed with ADHD. By definition, this group has no diagnosing physician in the data. Instead, we identify the first doctor a patient who was never diagnosed with ADHD saw when he or she was eight years old. It is the mean age of ADHD diagnosis in our sample of diagnosed children.[24]

Table 2.4 presents results for the undiagnosed sample as well as the reduced form regression estimates for the diagnosed sample. The point estimates of the coefficients on the propensity to prescribe have large confidence intervals suggesting that there is no statistically significant relationship between provider quality and propensity to prescribe.

2.5.2.2 Diagnosing provider selection

Another kind of potential bias may arise if parents of children with relatively severe symptoms of ADHD seek and use prior information about the provider's propensity to

[24]Due to a high provider mobility in and out of Medicaid, not all first-in-sample provider IDs were matched to the diagnosing provider IDs.

Table 2.4: IV Validity: Placebo Test

	STD	**STD +test**	**Subst. abuse**	**Teen Preg.**
Panel A. Undiagnosed Children				
Propensity to Prescribe	0.009	0.004	-0.003	-0.013
	(0.009)	(0.012)	(0.008)	(0.008)
Male	-0.079^{a}	-0.158^{a}	0.036^{a}	-
	(0.006)	(0.007)	(0.006)	-
Race: Black	-0.031^{a}	-0.017^{c}	-0.056^{a}	-0.017^{b}
	(0.009)	(0.010)	(0.009)	(0.008)
Hispanic	-0.045^{a}	-0.038^{b}	-0.047^{a}	-0.010
	(0.016)	(0.019)	(0.015)	(0.014)
Other	0.002	-0.016	-0.071^{a}	-0.018
	(0.021)	(0.025)	(0.017)	(0.018)
Number of adults	0.0004	-0.004	-0.005	-0.008
	(0.005)	(0.006)	(0.005)	(0.005)
Number of children	-0.006^{b}	-0.005	0.006^{b}	0.013^{a}
	(0.003)	(0.004)	(0.003)	(0.003)
Family net income	0.002	-0.007	-0.013^{a}	-0.014^{a}
	(0.004)	(0.005)	(0.004)	(0.004)
N obs.	10,743	10,743	10,743	7,938
Panel B. Children Diagnosed with ADHD				
Propensity to Prescribe	-0.017^{c}	-0.037^{a}	-0.059^{a}	-0.019
	(0.010)	(0.012)	(0.020)	(0.021)
Male	-0.129^{a}	-0.210^{a}	0.048^{a}	-
	(0.007)	(0.008)	(0.008)	-
Race: Black	-0.011^{c}	0.014	-0.076^{a}	-0.023^{c}
	(0.007)	(0.008)	(0.010)	(0.013)
Hispanic	-0.037	-0.019	-0.122^{a}	-0.064^{c}
	(0.022)	(0.027)	(0.027)	(0.037)
Other	-0.023^{c}	-0.039^{a}	-0.089^{a}	-0.075^{a}
	(0.012)	(0.014)	(0.016)	(0.024)
Number of adults	-0.006^{c}	-0.019^{a}	-0.019^{a}	-0.016^{c}
	(0.004)	(0.005)	(0.006)	(0.008)
Number of children	0.006^{b}	0.013^{a}	0.011^{a}	0.034^{a}
	(0.002)	(0.003)	(0.003)	(0.005)
Family net income	-0.002	-0.008	-0.028^{a}	-0.023^{a}
	(0.004)	(0.006)	(0.005)	(0.008)
N obs.	14,736	14,736	14,736	5,570

Notes: Panel A and B show the results of the IV validity test. Propensity to prescribe ADHD medication is constructed using the individual's provider at the mean age of ADHD diagnosis for the non-ADHD sample. The coefficients in Panel A are estimated on the sample of children who do not have ADHD using OLS. The dependent variables take value of one if a child experienced each of the respective adverse events; it is zero otherwise. The coefficients in Panel B are from the reduced form equation: regressing the outcome on doctor propensity to prescribe. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with a, b, and c respectively. Standard errors are in parentheses. They are clustered by individual's provider.

prescribe. If they, on average, visit physicians with a relatively high propensity to prescribe, this could bias our findings of the effects of ADHD medication downward. Similarly, if the parents of children with relatively less severe ADHD symptoms seek pharmacological treatment, it could result in an upward bias in our findings.

We do not have a strong prior on the direction of the bias. The medical evidence on the effectiveness of ADHD medication is mixed and the evidence on long-term effects is very limited. Additionally, there is a large array of potential side effects associated with these drugs. They include sleep problems, suppressed appetite, nausea, headaches, stunted growth, aggression and irritability, and cardiac risks (Barkley (2006)). Parents have to weigh the expected benefits and costs associated with medicating their child.

Table 2.5 reports the estimates of the relationship between physician propensity to prescribe and observed individual, mother, and family characteristics. They include mother's age and educational attainment at the time she gave birth, family net income measured at the time of the individual's first ADHD diagnosis, the severity of ADHD, and comorbid psychiatric conditions diagnosed prior to ADHD. We find no evidence of a consistent relationship between these observed characteristics and our instrumental variable except for a tightly-estimated small in magnitude effect for the family composition, patient gender, and race. For example, a family with one child versus two children would face a doctor with only 0.3 percentage points lower prescribing probability. The estimates also suggest that boys face providers who, on average, have a 1 percentage point higher propensity to prescribe than girls; and Blacks are diagnosed by providers with 2 percentage points lower propensity to prescribe than Whites. It is hard to think of a reason why conditional on ADHD severity, provider propensity to prescribe would be correlated with patient gender and race. In fact, when compared to the mean propensity to prescribe of 0.62, it becomes clear that our estimates reveal precisely that: nearly zero tightly-estimated relationship.

Building on the concerns identified in the earlier literature (Dalsgaard et al. (2014), Currie et al. (2014)) we look at the relationship between provider propensity to prescribe and patient family socio-economic status. We find a very small and statistically insignificant correlation between family income and provider propensity to prescribe. An increase of \$400 in monthly family income (median income in our sample) would imply a 0.8 percentage points lower provider propensity to prescribe. Medicaid enrollees are a relatively homogeneous group income-wise and are well-suited for our research design. Finally, we find no statistically significant relationship between provider propensity to prescribe and the severity of the underlying condition approximated by the history of injuries prior to the ADHD diagnosis.

Although there are many unobserved characteristics that could have an impact on the choice of the ADHD provider, we argue that our test has significant power. Covariates like family income and mother's characteristics have a long history of being used as predictors of health, parent quality, and other outcomes that we could be potentially concerned about.

2.5.2.3 Treatment shopping

About 10% patients in our sample (5,734 individuals) switch their health care provider after being diagnosed with ADHD. If the reason behind a switch is a patient's desire to alter their treatment, it could undermine our research design. In particular, the concern is that patients are shopping for treatment and if the first physician did not prescribe medication, they would search for a provider who would. For these patients, we look at the relationship between prescribing practices of the diagnosing physician and their subsequent physician. Of the individuals that switch providers, 57.6% go to a subsequent provider with a higher propensity to prescribe than the diagnosing provider; 39.4% go to a subsequent provider with a lower propensity to prescribe, and 3.0% go to a subsequent provider with a propensity to prescribe equal to the first diagnosing provider. Approximately 83% of switchers receive pharmaceutical treatment and 79% of those who do not switch receive pharmaceutical treatment.

Figure 2.2 plots this relationship. It shows no clear linear pattern in the switchers' behavior, suggesting that individuals who switch to a subsequent provider do so randomly or for reasons independent of the provider propensity to prescribe. We also look for the possibility of a nonlinear relationship. The coefficient on the quadratic term is small, positive and significant (0.07 (0.01)).[25] It suggests that for patients who first encounter providers with "extreme" prescribing preferences (either prescribe to no one or prescribe to all patients) and switch to another provider, their subsequent provider propensity to prescribe is slightly higher than average. If we regress the individual decision to switch on an indicator of provider being "extreme", we find that their patients are 2 percentage points more likely to switch providers (Table 19).

Further, we find no evidence of correlation between provider switching and mother's education or income (Table 19), and the mean values of mother and family characteristics do not differ significantly for individuals who go to a higher prescribing subsequent provider in relationship to individuals who go to a lower prescribing subsequent provider (Table 20). All these patterns suggest that strategic treatment shopping in our sample is not a significant issue but it also indicates that patients might be driven away from providers with the extreme preferences to prescribe ADHD medication.

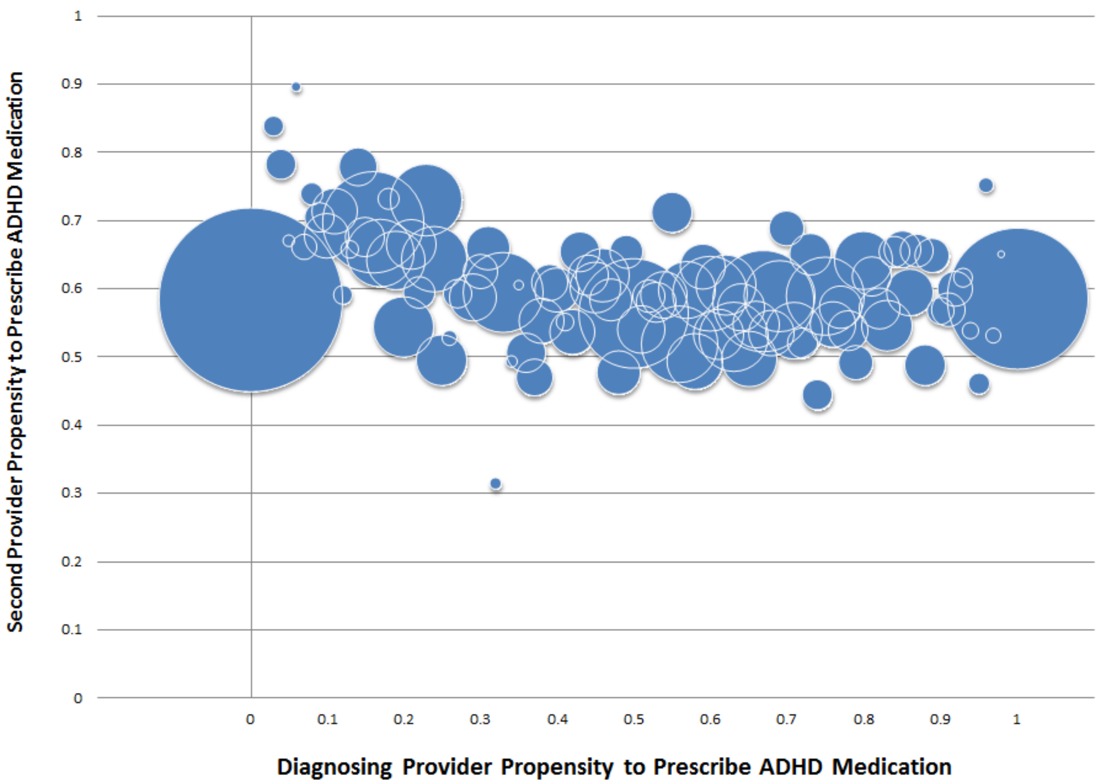
2.5.2.4 Provider propensity to prescribe and the length of Medicaid enrollment

The final test we perform is concerned with the length an individual is enrolled in Medicaid. In the data, we observe the individual so long as they are enrolled. If the decision to enroll in Medicaid is related to doctor propensity to prescribe, it is a potential concern for the identification strategy.

For example, if a patient was diagnosed by a provider with a relatively high propensity to prescribe and received medication, it is plausible to suggest that she may remain enrolled for a longer period of time than otherwise. One might argue that the longer an individual is enrolled, the more probable it is that we will observe a negative health outcome for that individual: STD contraction, STD screening, substance abuse disorder, or teenage

[25] The coefficient estimates do not change when controls from our main regression specification are included.

Figure 2.2: Provider Shopping: Diagnosing and Subsequent Provider Propensity to Prescribe



Notes: In the data, 5,734 patients switch health care providers. This figure shows the relationship between the individual's diagnosing provider propensity to prescribe and their subsequent provider propensity to prescribe. Prescribing propensities vary from zero to one.The bubble size indicates the number of patients for each pair of propensity scores.

pregnancy.[26] Positive correlation between doctor propensity to prescribe and enrollment could bias our results towards finding that pharmaceutical treatment receipt, instrumented with provider propensity to prescribe, is correlated with worse patient outcomes.

Table 2.5 shows that the instrument is uncorrelated with the length of Medicaid enrollment. In other words, individuals are not selecting into the sample based on their diagnosing provider propensity to prescribe.

Table 2.5: IV Validity: Additional Evidence

Dependent Variable:	**Propensity to Prescribe**		**Enrollment Length**	
Regressors	**Coeff.**	**SE**	**Coeff.**	**SE**
Individual Characteristics				
Male	0.011^a	0.003	-0.081^a	0.016
Race: Black	-0.020^a	0.003	0.292^a	0.017
Hispanic	-0.049^a	0.009	0.171^a	0.057
Other	-0.035^a	0.005	0.187^a	0.036
Mother & Family Characteristics				
Educ: Less than HS	0.002	0.006	0.103^b	0.039
Some HS	-0.002	0.003	0.077^a	0.018
Some college	-0.004	0.004	-0.269^a	0.024
College degree or higher	0.003	0.006	-0.406^a	0.036
Family net income	-0.002	0.002	-0.083^a	0.010
Number of adults	0.004^b	0.002	0.051^a	0.013
Number of children	0.003^b	0.001	0.059^a	0.007
Comorbid condition	-0.002	0.003	0.135^a	0.016
Severity of ADHD	-0.001	0.003		
Provider Propensity to Prescribe			0.006	0.028
N obs.	39,753		42,140	

Notes: This table shows two additional tests in support of our instrumental variable. Both regressions are estimated using OLS and include birth cohort and county fixed effects. Family income is measured in thousands of dollars; ADHD severity is approximated by the incidence of injuries prior to ADHD diagnosis. Family characteristics are measured and fixed at the time of the individual's first ADHD diagnosis. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with *a*, *b*, and *c* respectively.

[26] Due to the easiness of enrollment in Medicaid and including the fact that the program would cover up to two months of claims retroactively, these adverse outcomes would likely result in an individual re-enrollment and would not pose a risk for the model identification.

2.6 Results

We find evidence that ADHD medication treatment reduces the probability and severity of a wide range of short-term and lifetime negative health outcomes. It is effective in reducing the probability of an ADHD teenager contracting an STD, becoming pregnant, suffering from a substance use and abuse disorder, and having an injury.

Tables 2.6–2.9 summarize these results. For every negative health outcome we show coefficients estimated using IV and OLS, for comparison purposes. OLS estimates agree with the IV-estimated coefficients in the direction of the effect, but in most cases they understate the magnitude of the beneficial effects associated with treatment.

2.6.1 Lifetime Effects of ADHD Treatment

We first look at the effect of treatment on the incidence of negative health events over the childhood and teenage years. Table 2.6 summarizes the results. We find that medication is effective in reducing the probability of the outcomes produced by risky behaviors. Children with ADHD, who received pharmacological treatment are 3.6 percentage points less likely to be treated for an STD condition, 5.8 percentage points less likely to be screened for an STD/have a condition, and 7.3 percentage points less likely to receive medical attention related to a substance abuse disorder. The point estimate on the probability of teenage pregnancy is also negative (-2.3 percentage points) but not statistically significant.[27]

Compared to the OLS estimates, the coefficients obtained using IV are of the same sign for all outcomes, but are larger in absolute value and statistically significant for STD contraction, STD screening and substance abuse disorder. In other words, OLS understates the effects of treatment but indicates that treatment has favorable effects on outcomes.

The results also show that males are less likely to be treated (12.0 percentage points) or screened (20.5 percentage points) for an STD but 4.1 percentage points more likely to have medical history of substance abuse. This finding is consistent with the reports on

[27]These results generally hold in a smaller sample of patients for whom we have birth certificate data. Table 21 shows the effects of ADHD treatment on negative outcomes when we control for mother's age and educational attainment.

STDs.[28] For example, the chlamydia case rate per 100,000 females in 2005 was more than three times higher than for males. Most of this difference is attributed to the fact that women are more likely to be screened than men. Whites are the most likely to suffer from one of the negative health outcomes that we focus on, which is also likely to be an outcome of higher probability of being screened.

Family characteristics that we control for include family composition (number of adults and children in the individual's household) as well as family net income at the time of the child's diagnosis. The coefficients on these controls are consistent with our prior. In a family with a single adult comparing to a family with two adults, the probability of negative health outcomes is 0.6-1.6 percentage points lower depending on the type of the outcome. This result is statistically significant for the STD condition and screening combined, substance abuse, and teen pregnancy.

On the other hand, individuals in families with a higher number of children are more likely to experience one of the negative health outcomes. The magnitude of the effect varies from 0.6 to 3.4 percentage points, being the highest for teenage pregnancy. It is likely due to the fact that there is relatively less parental oversight in larger families. Finally, net family income is negatively correlated with the incidence of risky behavior outcomes. As we would expect, the better off the family is in terms of income, the less likely their child will experience a negative health outcome, however the magnitude of the effect is very low. A $100 increase in the net monthly income would produce a 0.02, 0.08, 0.27, and 0.23 percentage point decrease in the probability of STD, STD screening, substance abuse, and teen pregnancy respectively. Note that most families on Medicaid are relatively poor and there is not enough income variation in this population group to evaluate the effect of income on the incidence of negative health outcomes.

Table 22 in the Appendix shows that the results are robust to including a control for comorbid psychiatric conditions that an individual is diagnosed with prior to their ADHD diagnosis. When we exclude individuals who have been diagnosed with a comorbid

[28] CDC, "Trends in Reportable Sexually Transmitted Diseases in the United States, 2005", http://www.cdc.gov/std/stats05/trends2005.htm. Accessed on July 14, 2015.

psychiatric condition prior to their ADHD diagnosis, our results hold for all the outcomes.

We also explore how our results vary across ADHD-diagnosed patients of different gender, race, and birth cohort. The results are reported in Table 2.7. These stratifications provide us with interesting insights. The results for male and female subpopulations suggest that treatment reduces the probability of STD contraction and STD screening for both males and females but estimates are statistically significant only for females. As previously discussed, females have a higher prevalence of STDs likely due to the fact that they are screened for STDs more often than males. Treatment also reduces the probability of abusing substances for both males and females but the effect is only statistically significant for males.

For most outcomes we find little heterogeneity across races. Treatment reduces the probability of STD contraction, STD testing and substance abuse for both Whites and minorities; however the point estimates are imprecise for Whites. Finally, treatment is associated with a statistically insignificant reduction in the probability of teenage pregnancy for Whites; for minorities the point estimate is nearly zero and imprecise.

Following earlier research, we split patients by the year of birth into two groups: relatively "older" and "younger" cohorts. Our results are consistent with Dalsgaard et al. (2014), who find treatment to be less effective in younger cohorts. We interpret this result in light of increased incidence of ADHD diagnosis. It is suggestive of the average ADHD case being less severe in relatively younger cohorts than in older cohorts.

2.6.2 Yearly Effects of ADHD Treatment

Perhaps an even more policy-relevant question is what is the difference in outcomes for children who are treated with ADHD medication versus children who are not in per year terms. The average cost of a prescription medication is $347 per patient per year and the average cost of ADHD-related physician visits is $562 per patient per year during the sample period (measured in 2013 dollars). It is valuable to compare these treatment expenditures to what Medicaid spends on treatment of realized negative health outcomes.[29]

[29] It is one of the goals of our future work to differentiate these effects by the year of diagnosis, adherence status, and length of treatment.

Table 2.6: Lifetime Effects of ADHD Treatment on Negative Health and Behavioral Outcomes

	STD		**STD+test**		**Subst. abuse**		**Pregnancy**	
	OLS	**IV**	**OLS**	**IV**	**OLS**	**IV**	**OLS**	**IV**
First stage		0.517^a		0.512^a		0.516^a		0.545^a
		(0.033)		(0.034)		(0.034)		(0.037)
ADHD Treatment	-0.012^b	$\mathbf{-0.036}^c$	-0.015^b	$\mathbf{-0.058}^b$	-0.004	$\mathbf{-0.073}^b$	-0.030^b	**-0.023**
	(0.005)	**(0.019)**	(0.007)	**(0.023)**	(0.008)	**(0.036)**	(0.012)	**(0.038)**
Male	-0.121^a	-0.120^a	-0.207^a	-0.205^a	0.038^a	0.041^a		
	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)		
Race: Black	-0.009	-0.012^c	0.016^c	0.011	-0.074^a	-0.082^a	-0.023^c	-0.022
	(0.006)	(0.007)	(0.008)	(0.009)	(0.009)	(0.010)	(0.013)	(0.014)
Hispanic	-0.042^b	-0.044^b	-0.032	-0.036	-0.110^a	-0.116^a	-0.073^b	-0.072^b
	(0.021)	(0.021)	(0.025)	(0.025)	(0.025)	(0.025)	(0.036)	(0.036)
Other	-0.018	-0.019^c	-0.029^b	-0.032^b	-0.091^a	-0.095^a	-0.069^a	-0.068^a
	(0.011)	(0.011)	(0.014)	(0.014)	(0.017)	(0.017)	(0.024)	(0.024)
Number of adults	-0.007^c	-0.006^c	-0.017^a	-0.016^a	-0.016^a	-0.016^a	-0.015^c	-0.015^c
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.006)	(0.008)	(0.008)
Number of children	0.006^a	0.006^a	0.012^a	0.012^a	0.010^a	0.009^a	0.034^a	0.034^a
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)
Family net income	-0.002	-0.002	-0.009^c	-0.008	-0.027^a	-0.027^a	-0.023^a	-0.023^a
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.008)	(0.008)
Mean outcome	0.117		0.212		0.236		0.265	
N obs.	14,248		13,896		13,668		5,339	

Notes: The main coefficient estimates (in bold) in this table can be interpreted as the effect of treatment within a year of the individual's ADHD diagnosis on the probability of a negative health outcome during an individual's adolescence. All specifications include individual county of residence and birth year fixed effects. We also control for the individual's age and net family income at first ADHD diagnosis, length of Medicaid eligibility, disability and foster care status. First stage coefficients show the relationship between treatment receipt within a year of the individual's ADHD diagnosis and physician propensity to prescribe medication. Negative health outcomes are considered a year or more after the individual's ADHD diagnosis. All specifications are estimated on a subsample of relevant birth cohorts of SC Medicaid enrollees and include individuals born between 1987 and 1996. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with a, b, and c respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

Table 2.7: Heterogeneity of the Effects of ADHD Treatment on (lifetime) Outcomes

Group	**STD**	**STD +test**	**Subst. abuse**	**Teen Preg.**
Panel A. Gender-based heterogeneity				
Male	-0.007	-0.035	-0.096^b	–
	(0.020)	(0.026)	(0.042)	
Mean	0.067	0.127	0.239	–
N	8,985	8,887	8,502	
Female	-0.089^a	-0.117^a	-0.047	–
	(0.032)	(0.039)	(0.045)	
Mean	0.203	0.364	0.231	–
N	5,263	5,009	5,166	
Panel B. Race-based heterogeneity				
White	-0.032	-0.042	-0.072	-0.079
	(0.036)	(0.040)	(0.053)	(0.063)
Mean	0.122	0.199	0.266	0.280
N	6,410	6,256	6,179	2,648
Minorities	-0.043^b	-0.068^b	-0.084^b	0.018
	(0.021)	(0.027)	(0.042)	(0.044)
Mean	0.115	0.225	0.216	0.255
N	7,640	7,450	7,297	2,615
Panel C. Cohort-based heterogeneity				
Old	-0.047	-0.093^b	-0.154^b	-0.130^c
	(0.033)	(0.040)	(0.064)	(0.076)
Mean	0.120	0.194	0.247	0.373
N	3,692	3,552	3,404	1,359
Young	-0.027	-0.040	-0.039	0.021
	(0.022)	(0.027)	(0.035)	(0.041)
Mean	0.116	0.219	0.232	0.228
N	10,556	10,344	10,264	3,980

Notes: This table reports the coefficient on ADHD treatment from the Equation 5 estimated on three subpopulations, stratified by gender, race, and birth cohort. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with a, b, and c respectively. Standard errors are in parentheses.

The results suggest that pharmaceutical treatment is associated with a 1.1 percentage point decrease in the probability of contracting an STD, a 1.9 percentage point decrease in the probability of being screened for an STD, a 1.8 percentage point decrease in the probability of abusing substances, and a 2.3 percentage point decrease in the probability of being injured, or a reduction of 0.081 injuries in a given year. Our findings for injuries are in line with the findings of Dalsgaard et al. (2014).

The panel analysis results reported in Table 2.8 are consistent with our cross-section analysis: we find that treatment is associated with a reduction in the probability of contracting an STD, being screened for an STD, and abusing substances. The magnitudes of the coefficients in the yearly effects regressions are complementary rather than directly comparable to the lifetime effects of ADHD treatment. In the former we specifically focus on the periods of the child's continuous enrollment in Medicaid, controlling for the patient's age and other time-varying parameters.

The coefficients on covariates of interest also support the earlier reported results on the lifetime effects of treatment. For the probability of injuries, the signs are as expected. Boys are 2.8 percentage points more likely than girls to have an injury in a given year. Whites are more likely to suffer from most negative health outcomes, including injuries, than Blacks and Hispanics. We posit that this is related to the likelihood of using medical services in general, as discussed earlier.

2.6.3 Effects of ADHD Treatment on Medicaid Spending

Only occasionally ICD-9 diagnosis codes and CPT procedure codes that we used to identify the incidence of negative health outcomes, are indicative of severity of the underlying condition. It is plausible, however, that ADHD medication has an effect not only on the incidence of the negative health events but also on their severity. A way to address this question is to look at the direct cost to Medicaid of the outcomes that we observe in the data (with an exception of pregnancy). We posit that the more visits are needed and the higher is the bill, the more severe is the patient's condition. If a patient experienced

Table 2.8: Yearly Effects of ADHD Treatment on Health and Behavioral Outcomes

	STD		STD+test		Subst. abuse		Pregnancy		Injury (0/1)		N Injuries	
	OLS	**IV**	**OLS**	**IV**	**OLS**	**IV**	**OLS**	**IV**	**OLS**	**IV**	**OLS**	**IV**
First stage		0.534^a		0.534^a		0.539^a		0.570^a		0.443^a		0.443^a
		(0.039)		(0.038)		(0.040)		(0.043)		(0.027)		(0.027)
ADHD	-0.004^a	$\mathbf{-0.011}^b$	-0.005^b	$\mathbf{-0.019}^a$	-0.002	$\mathbf{-0.018}^c$	-0.007^b	**-0.003**	-0.006^b	$\mathbf{-0.023}^c$	-0.025^a	$\mathbf{-0.081}^b$
Treatment	(0.001)	**(0.004)**	(0.002)	**(0.006)**	(0.002)	**(0.009)**	(0.003)	**(0.010)**	(0.003)	**(0.013)**	(0.007)	**(0.031)**
Male	-0.028^a	-0.028^a	-0.053^a	-0.053^a	0.009^a	0.011^a	–	–	0.027^a	0.028^a	0.068^a	0.071^a
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)			(0.002)	(0.002)	(0.006)	(0.006)
Race: Black	-0.001	-0.002	0.005^b	0.004	-0.018^a	-0.020^a	-0.007^b	-0.007^c	-0.047^a	-0.049^a	-0.129^a	-0.134^a
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.003)	(0.003)	(0.007)	(0.007)
	-0.010^c	-0.011^c	-0.007	-0.008	-0.027^a	-0.029^a	-0.023^c	-0.022^c	-0.070^a	-0.072^a	-0.144^a	-0.152^a
	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.012)	(0.012)	(0.009)	(0.009)	(0.021)	(0.021)
N adults	-0.002	-0.001	-0.030^a	-0.030^a	-0.007^a	-0.007^a	-0.012^a	-0.012^a	0.009^a	0.009^a	0.017^a	0.017^a
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)
N children	0.001	0.000	-0.002	-0.004	-0.001	-0.001	0.010^a	0.010^a	0.002	0.001	-0.001	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Family income	-0.002^b	-0.002^b	-0.003^a	-0.003^a	-0.006^a	-0.006^a	-0.011^a	-0.011^a	-0.008^a	-0.008^a	-0.018^a	-0.018^a
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.003)	(0.003)
Mean outcome	0.024		0.046		0.050		0.055		0.266		0.464	
N obs.	68,378		64,622		64,328		25,666		266,181		266,181	

Notes: The main coefficient estimates (in bold) in this table can be interpreted as the average annual effect of treatment on the probability of a post-diagnosis negative health outcome. Treatment is defined as treated within a year of the individual's ADHD diagnosis. All specifications include individual's county of residence fixed effects, year fixed effects, and their interactions. We also control for the individual's disability and foster care status. The coefficients on the number of children and adults in the family are scaled up by 10 in the STD and STD screening regressions in order to report their magnitudes. First stage coefficient shows the relationship between treatment receipt and physician propensity to prescribe medication. Negative health outcomes are considered a year or more after the individual's ADHD diagnosis. All specifications except for injuries are estimated on a subsample of relevant birth cohorts of SC Medicaid enrollees and include individuals born between 1987 and 1996. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with a, b, and c respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

an adverse event, we use Medicaid payments to the providers to calculate the cost of this outcome. The cost is zero if a patient did not experienced a negative health outcome.[30]

Panel A of Table 2.9 shows the results for the average annual cost to Medicaid over the patients' lifetime enrollment period for STD, STD screening, substance abuse, and injuries. In Panel B, we look at the data in per year terms and control for patient age and other time-varying characteristics. If a patient is treated for ADHD, every patient per year would cost Medicaid \$10.34 (\$20.64) less in STD-related expenses (if we include STD tests); \$93.68 less in substance abuse-related costs, and \$88.37 fewer in injury spending. In relative terms, treatment reduces spending on substance abuse disorders by 0.061 of a standard deviation and injury spending by 0.054 of a standard deviation.

Note that both lifetime and per year effects of treatment on the incidence of STD and STD combined with screening are large and negative, but the effects on costs related to these events are rather modest. This is likely due to the difficulty of measuring STD-related costs. Our STD cost measure only includes expenses related to provider visits. The most billing procedure codes that go along with an STD diagnosis are one-time screening and the visit itself. By construction, STD spending will have no-charge periods with intermittent chargers for STD test and office visit in the absence of pharmacological treatment spending information. Thus, our STD spending measure is understating the effect.

For one of our outcomes, substance abuse, we were able to take advantage of the earlier literature to construct a comprehensive cost measure that includes medical doctor visits and the cost of pharmacological treatment. We are not aware of methodological work that would help us construct the same measure for STDs. This might explain the fact that the results on the incidence and cost of substance abuse are better aligned than the results for STD.

OLS estimates that we present for comparison purposes, have the same sign as the IV estimates, but are mostly noisy.

[30] Medicaid payments are CPI-adjusted to 2013 dollars.

Table 2.9: Effects of ADHD Treatment on the Costs of ADHD-associated Negative Health Outcomes to Medicaid

	STD		**STD+test**		**Subst. abuse**		**Injury**	
	OLS	**IV**	**OLS**	**IV**	**OLS**	**IV**	**OLS**	**IV**
Panel A: Effects of ADHD Treatment on Medicaid Costs of Negative Health Outcomes per Year of Enrollment								
First stage		0.539^a		0.539^a		0.539^a		0.458^a
		(0.032)		(0.032)		(0.032)		(0.025)
Treatment	-2.81	**8.76**	-6.84	**1.95**	-27.83	**-162.70**^{b}	-17.79	**-58.13**
	(6.250)	**(16.05)**	(6.26)	**(17.04)**	(21.13)	**(79.15)**	(11.12)	**(39.75)**
Mean outcome	20.18		34.83		224.13		191.38	
	(251.72)		(261.26)		(1,028.60)		(1,145.76)	
N obs.	9,575		9,575		9,575		58,405	
Panel B: Yearly Effects of ADHD Treatment on Medicaid Costs of Negative Health Outcomes (Panel)								
First stage		0.540^a		0.540^a		0.540^a		0.438^a
		(0.037)		(0.037)		(0.037)		(0.027)
Treatment	-6.31	**-10.34**	-8.53^c	**-20.64**^{c}	-19.11	**-93.68**^{c}	-26.23	**-88.37**^{b}
	(4.65)	**(10.96)**	(4.35)	**(11.63)**	(14.25)	**(50.78)**	(10.33)	**(36.96)**
Mean outcome	17.85		31.37		158.84		191.29	
	(328.97)		(345.42)		(1,524.39)		(1647.51)	
N obs.	74,016		74,016		74,016		233,149	

Notes: The main coefficient estimates (in bold) in Panel A can be interpreted as the effect of treatment within a year of the individual's ADHD diagnosis on the average cost of ADHD-related post-diagnosis negative health outcomes to Medicaid per year of uninterrupted individual's enrollment. In Panel B, we control for time-varying characteristics and the coefficients can be interpreted as the effect of ADHD treatment within a year of the individual's ADHD diagnosis on the average annual cost of negative health outcomes to Medicaid. All specifications in Panel B include individual county of residence fixed effects, year fixed effects, and their interactions. Medicaid spending is adjusted to 2013 dollars. First stage coefficients show the relationship between treatment receipt and physician propensity to prescribe medication. All specifications except for injuries are estimated on a subsample of relevant birth cohorts of SC Medicaid enrollees and include individuals born between 1987 and 1996 who were eligible for Medicaid at age of 11 years old or later. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with a, b, and c respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

2.7 Robustness

We perform several robustness checks. First, we test the sensitivity of the results to alternative definitions of pharmacological treatment. Our findings have the same signs on the coefficients of interest and differ from the baseline specification results in an expected way. Second, we introduce two alternative instrumental variables: the first-in-data provider propensity to prescribe and a geographic instrument based on child's school location. The alternative IVs would be expected to have weaker explanatory power but they are arguably more exogenous. Both instruments provide evidence compatible with our preferred instrument. The summary of the results is shown in Table 2.10. Each row represents the three different treatment definitions; and reports both the first stage coefficient and the coefficient on treatment instrumented with an alternative IV and our preferred instrument for comparison purposes.

2.7.1 Alternative definition of treatment

Pharmacological treatment can be defined in a number of ways. Our baseline definition considers an individual as treated if they have a record of taking any medication approved for ADHD within a year of their ADHD diagnosis. Alternatively, we could assign the treated status to individuals who ever take a prescription after their ADHD diagnosis. Whereas our baseline definition of treatment assumes that the instrument only has an effect on treatment receipt within a year of the individual's ADHD diagnosis (and has no effect on outside treatment channels), this definition of treatment requires a less strict assumption of the exclusion restriction. The relationship between the provider propensity to prescribe medication and treatment under this definition is weaker, as expected (Table 2.10). The estimation yields relatively larger point estimates for treatment in absolute value compared to our baseline specification. This result might be explained by the fact that 7% patients receive treatment later than a year since the initial diagnosis and did not experience negative outcomes, but are being coded as never treated in our baseline specification.

For the second test, we follow earlier literature (see Dalsgaard et al. (2014)) and assign treatment status to the individuals who were treated for at least 6 months in a given year. This definition captures the idea of treatment adherence. Indeed, one prescription would not cure or even alleviate the condition, but half a year of treatment is more likely to have an impact on the child's health and behavioral outcomes. Again, by construction, the relationship between the provider propensity to prescribe medication and treatment adherence of six months or more is weaker (Table 2.10). Perhaps not surprising, when we define the treated population as only those who adhere to treatment for six months, we find treatment to be more effective.

We present these results for comparison purposes and we argue that our baseline treatment accounts for the timing of treatment and occurrence of negative health events. Under the definition of "ever treated", we can not exclude the possibility that some individuals would be first diagnosed with ADHD, then experience an adverse outcome, and only then receive treatment. The other alternative treatment definition, "filling 6 prescriptions or more in a given year", is hard to defend against the argument that the provider might influence adherence to treatment and health outcomes through channels other than the act of simply prescribing medication. In other words, our IV estimates can be interpreted as a lower bound on the effects of treatment on negative health outcomes.

2.7.2 Alternative instrumental variables

We construct two alternative instrumental variables and test them on the treatment definitions described above. First, we calculate provider propensity to prescribe index for the the first-in-data provider rather than the diagnosing provider. The purpose behind this IV is to address potential concerns about the provider selection based on the probability they would prescribe medication. We argue that children visit their pediatrician or family physician routinely, for most health issues, including ADHD, rather than selecting a specific provider to go to with ADHD-related concerns. We calculate a measure of prescribing preferences for the first-in-data provider based on all patients with ADHD the provider diagnosed in that year. Note that not all providers have patients with ADHD every year and there is also a significant provider mobility in and out of Medicaid. For this reason, we do not have a first-in-data provider propensity to prescribe for everyone who was diagnosed with ADHD in our sample.

In line with our main specification findings, the results utilizing the first-in-data provider preferences suggest that treatment reduces the probability of STD contraction, STD screening, and substance abuse disorders (Table 2.10). A smaller sample size likely explains the increase in the noisiness of our coefficient estimates. These results provide additional support to the evidence we presented on the absence of provider selection (Section 2.5).

Next, we define a geographic area-based alternative instrument. It is constructed using the school a patient is attending. We take the fraction of other students treated with medication divided by the total number of students diagnosed with ADHD in the individual's year of diagnosis at the school. The results suggest that treatment reduces the probability of STD contraction, STD screening, and abusing substances, however the estimates are noisy likely due to the relatively weaker first stage. The first stage estimates are statistically weak for treatment defined as treated for at least 6 months in a given year and for this reason are not reported.

Table 2.10: Robustness: Alternative Instrumental Variable and Treatment Definitions

Treatment definition	STD			STD+test			Subst. abuse		
	Baseline	1st provider	School PP	Baseline	1st provider	School PP	Baseline	1st provider	School PP
Baseline: 1+ Rx within the 1st year									
First Stage	0.517^a	0.123^a	0.092^a	0.512^a	0.123^a	0.089^a	0.516^a	0.126^a	0.093^a
	(0.014)	(0.018)	(0.014)	(0.014)	(0.018)	(0.015)	(0.014)	(0.018)	(0.015)
ADHD Treatment	-0.036^c	-0.041	-0.091	-0.058^b	-0.126	-0.195	-0.073^b	-0.046	-0.082
	(0.020)	(0.099)	(0.116)	(0.023)	(0.110)	(0.146)	(0.040)	(0.149)	(0.147)
Ever Treated									
First Stage	0.468^a	0.122^a	0.085^a	0.463^a	0.122^a	0.083^a	0.465^a	0.122^a	0.088^a
	(0.014)	(0.018)	(0.014)	(0.014)	(0.018)	(0.014)	(0.014)	(0.018)	(0.014)
ADHD Treatment	-0.040^c	-0.042	-0.098	-0.064^b	-0.127	-0.210	-0.081^b	-0.046	-0.087
	(0.021)	(0.099)	(0.125)	(0.026)	(0.111)	(0.158)	(0.040)	(0.150)	(0.155)
6+ Rx ever (Dalsgaard et al. (2014))									
First Stage	0.200^a	0.071^a		0.201^a	0.071^a		0.199^a	0.071^a	
	(0.013)	(0.017)		(0.014)	(0.017)		(0.014)	(0.017)	
ADHD Treatment	-0.088^c	-0.072		-0.130^b	-0.218		-0.145	-0.079	
	(0.051)	(0.172)		(0.060)	(0.202)		(0.094)	(0.256)	
N obs.	14,248	7,338	12,299	13,896	7,338	12,183	13,668	7,338	12,178

Notes: "Baseline" column contains estimates for our preferred instrument – diagnosing provider propensity to prescribe. First provider IV uses prescribing preferences of the first-in-data provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with a, b, and c respectively. Standard errors are in parentheses. Standard errors are clustered by diagnosing provider for specification using diagnosing provider propensity to prescribe; standard errors are clustered by first provider for specification using first-in-data provider propensity to prescribe.

2.8 Conclusion

This paper investigates the effectiveness of ADHD medication in reducing the probability of short-term and long-term negative health outcomes associated with the disorder. Over the past decade, SC Medicaid spending on prescription drugs increased nearly threefold to $69 million in 2013. It is important to understand whether the increased expenditures on treatment produced any benefit in terms of improved health (fewer and less severe injuries), reduction in risky behaviors that potentially lead to teen pregnancies, STDs, and substance use and abuse. The focus population of our study are children from relatively disadvantaged families who are enrolled in SC Medicaid and who are diagnosed with ADHD. This population is particularly vulnerable: up to a quarter of Medicaid enrollees are diagnosed with ADHD in their birth cohort. Although we are unable to make a statement on the effectiveness of ADHD treatment in general population, our sample represents a large fraction of the state population, and an even larger fraction of diagnosed children. Since children on Medicaid are disproportionately diagnosed with ADHD and their incentives are distorted in the absence of a drug price tag, this population should be of primary focus.

Our panel data set includes all SC Medicaid claims between 2003 and 2013. To overcome potential endogeneity of treatment take-up, we use variation in physician prescribing preferences for ADHD. Our findings suggest that ADHD medication is effective in reducing the probability of the negative health and behavioral outcomes that we are able to identify in administrative data. Based on our preferred specification, over the course of teenage years the probability of contracting an STD decreases by 3.6 percentage points; an individual is 5.8 percentage points less likely to be screened for an STD/have a condition; and 7.3 percentage points less likely to receive medical attention related to a substance abuse disorder if treated with ADHD medication. The point estimate on the probability of teenage pregnancy is also negative (-2.3 percentage points) but not statistically significant.

Controlling for time-varying characteristics, these findings translate into a 1.1 percentage point decrease in the probability of contracting an STD, a 1.9 percentage point decrease in the probability of being screened for an STD, a 1.8 percentage point decrease in the probability of abusing substances, and a 2.3 percentage point decrease in the probability of being injured, or 0.081 reduction in the number of injury-related medical procedures in a given year.

These results generally agree with the findings of Dalsgaard et al. (2014), who find that medication is effective in reducing the number of hospital contacts and the likelihood of criminal activity. However, Currie et al. (2014) find that an increase in medication use is associated with negative effects on children's educational outcomes, deterioration in relationships with parents, and increase in the probability of depression. These differences are suggestive of ADHD medication having varying effects on noncognitive human capital in comparison to cognitive abilities.

It is plausible to suggest that ADHD medication has an effect not only on the incidence of negative health outcomes but also on their severity. We go beyond the existing literature and address this question by looking at the direct cost to Medicaid of all outcomes that we observe in the data (except for pregnancy). We posit that the more visits are needed and the costlier they are, the more severe is the patient's condition. For every patient treated for ADHD, each year of eligibility would cost Medicaid an estimated \$10.34 (\$20.64) less in STD-related expenses (if we include STD tests); \$93.68 less in substance abuse-related costs and \$88.37 in injury spending. In per year terms, when we control for patient age and other time-varying characteristics, the results tell the same story and are very similar in magnitude.

The limitations of this study that we hope to address in future research include the scope of the effects of interest and external validity. First, our results reflect the effect of treatment of a marginal patient and do not attempt to measure the benefit of pharmaceutical treatment for children with ADHD that will inevitably be treated. Second, although our sample of Medicaid children makes up a large proportion of the population diagnosed with ADHD, the results are not necessarily generalizable to the non-Medicaid population. At the same time, the population in our study is the most affected by the negative health outcomes that children with ADHD are prone to, which makes our findings even more policy-relevant.

On average, SC Medicaid spent $347 for prescription medication and $562 on ADHD-related physician visits, including behavioral therapy, while the total savings across all negative health outcomes summed up to $221 on average per child per year. However, these “savings” do not include the costs associated with teenage pregnancies, any indirect benefits that stem from preventing negative health and behavioral outcomes, or any indirect benefits that accrue to the patients’ peers. We are also not able to estimate costs of side effects of the medication. With the increasing rates of ADHD diagnosis and respective government spending on programs like Medicaid as well as Medicaid expansion, comparison of treatment costs and benefits deserve special investigation in future work.

Chapter 3

Social Security Supplemental Security Income (SSI) Disability Benefits on Future Educational Achievement (with Timothy Bersak)

3.1 Introduction

Lower birth weight infants have worse health and academic outcomes. The detriments of low birth weight persist in the long-run and adversely affect adult schooling attainment and earnings (Behrman and Rosenzweig (2004), Black et al. (2007), Fletcher (2011)). The federal Supplemental Security Income (SSI) program provides cash transfers to individuals with low incomes and resources who are aged, disabled, or blind, including disabled children. There is no minimum age requirement necessary to establish a medically determinable impairment, and in practice some infants are found to be disabled and eligible for the SSI program from birth. Of particular note, under Disability Insurance listing 34005.100, low birth weight and failure to thrive, infants can be found eligible for SSI if they are born at a low weight relative to their gestational age, regardless of whether there are any additional impairments present. Because the exact weight thresholds are somewhat arbitrary this feature of the program provides an effectively random determinant of benefit receipt. Infants, that are otherwise observationally similar, differ in their eligibility for and receipt of benefits solely based upon which side of the threshold their birth weight happens to fall. As low birth weight is not the only criteria through which a child can establish a medically determinable impairment, there will be some infants who are born above the threshold that also qualify for SSI payments. The full list of thresholds is contained in the table below.

Table 3.1: Eligibility of SSI Receipt Weight and Gestational Age Thresholds

Gestational Age (weeks)	**Birth weight (grams)**	**Birth weight (lbs & oz)**
>=37-40	<=2000	4lbs & 6.50oz
>=36	<=1875	4lbs & 2.14oz
>=35	<=1700	3lbs & 11.97oz
>=34	<=1500	3lbs & 4.91oz
>=33	<=1325	2lbs & 14.74oz
>=32	<=1250	2lbs & 12.09oz
ANY	<1200	2lbs & 10.33oz

Source: SSA Program Operations Manual System

If an infant is eligible for SSI, the 2017 maximum federal benefit amount is 735 dollars per month, though this figure can be reduced depending on how much family income is deemed available to support the child. Typically, when infants are found eligible for SSI, their case will be reviewed after a period of two years to determine if the child continues to be eligible for the program. Absent any frictions, this means that the impact of birth weight relative to an eligibility threshold on benefit receipt should entirely disappear after the first two years of life, though in practice there is probably some persistence of benefit eligibility, meaning that future rates of disability receipt are likely to converge but not entirely equalize as a child ages.

This paper contributes to several important strands of literature. A large body of work has looked at the impacts of income and cash transfer programs on early childhood and educational outcomes. In a working paper, Guldi et al. (2017) exploit the discontinuity of the lowest birth weight threshold for SSI eligibility to estimate the impacts of supplemental security income on early childhood outcomes. Hoyne et al. (2016) exploit the sequential rollout of the Food Stamp program and find that increasing a family's economic resources during early childhood leads to improved health outcomes and an increase in economic self sufficiency later in life. Akee et al. (2010) find that unconditional cash transfer payments from casino profits increase educational attainment before the age of 21 for children in the poorest households. Their study also suggests that improved parental quality is the likely mechanism that drives improved outcomes. Maurin (2002) estimates that a 10 percent increase in family incomes is associated with a 6.5 percent decrease in the probability of repeating a grade during elementary school for children in France, suggesting potentially large impacts of social programs that provide cash transfers to low income families. Berger et al. (2009) estimate that higher incomes in early childhood are associated with better cognitive and behavioral outcomes at age 3, and their estimates are consistent with the hypothesis that the mechanism through which income improves outcomes is better parenting and home environments. Shea (2000) employs an instrumental variable strategy using variations in income that are arguably due to luck and estimates that parental income has a negligible impact on both the future earnings and educational achievement of children, although Shea finds some evidence that increased income improves outcomes for the children of parents with low levels of educations.

A secondary contribution of this paper is to the literature that investigates the relationship between low birth weight and future health and economic outcomes.

3.2 Data and Descriptive Statistics

We merge South Carolina birth certificate data with data on student academic records over the years 2003 to 2013. The academic performance measures are utilized for individuals in kindergarten through eighth grade.

The birth certificate data include vital statistics variables collected at the time of the child's birth: birth weight, gestational age, mother's age at birth, mother's education at birth, a measure of tobacco use medical risk, and the number of prenatal care visits. The

Department of Education data include measures of student performance: grade repetition, whether the individual has a registered learning disability, and elementary and middle school test scores (South Carolina Palmetto Assessment of State Standards), [1] To be included in our analysis, we require the infant to be within 200 grams of the birth weight thresholds.[2] Table 3.2 reports summary statistics for the academic outcome measures we consider in our analysis. We define grade repetition equal to 1 if the individual ever repeats a grade in elementary or middle school, and zero if not. Learning disabilities are recorded by the individual's school likely for special educational purposes. Finally, the test score outcomes are the average of the individual's English and mathematics standardized test scores by grade.

Using the individual's gestational age and birth weight, we determine if the individual is eligible for SSI disability benefits at birth using Table 3.1. In our main analysis, we include infants at all SSI birth weight eligibility cutoffs. For robustness, we exclude infants in the 1500 gram birth weight (<=34 gestational weeks) threshold as these individuals could also be treated by medical interventions (Almond et al., 2010). Table 3.3 reports the mean values for outcome measures and covariates by each birth weight threshold.

Table 3.2: Outcome Summary Statistics

	N obs.	**Mean**	**Std. Dev.**	**Min**	**Max**
Academic Outcome Measures					
Grade repetition	2384	0.180	0.384	0	1
Learning disability	2384	0.208	0.406	0	1
Average Mathematics & English Test Scores					
3rd grade	691	2.920	1.123	1	5
4th grade	751	2.728	0.991	1	5
5th grade	821	2.679	0.995	1	5
6th grade	840	2.598	1.044	1	5
7th grade	836	2.525	1.027	1	5
8th grade	824	2.419	0.998	1	5

Notes: The sample includes all observations within 200 grams of all birth weight thresholds.

[1] South Carolina Palmetto Assessment State Standards includes testing in subjects of English, math, science, social studies, and writing.

[2] For robustness, we also make use of a 150 gram bandwidth.

Table 3.3: Summary Statistics: Mean Values for Outcomes & Covariates by Threshold

	Threshold						
	<1200g	**<=1250g**	**<=1325g**	**<=1500g**	**<=1700g**	**¡=1875g**	**<=2000g**
Covariates							
Mother's age	24.036	24.624	25.117	24.9134	24.450	24.647	24.362
Mother's education	11.532	10.882	11.447	11.835	11.167	11.753	11.427
Tobacco risk measure	1.870	1.849	1.894	1.795	1.844	1.760	1.752
Male	0.467	0.473	0.489	0.354	0.402	0.339	0.326
# prenatal visits	7.317	8.830	9.303	9.276	10.949	10.437	10.777
Academic Outcome Measures							
Grade repetition	0.177	0.151	0.160	0.197	0.156	0.201	0.182
Learning disability	0.267	0.258	0.170	0.213	0.167	0.163	0.173

Notes: The sample includes all observations within 200 grams of all birth weight thresholds.

3.3 Empirical Strategy

Infants can be found eligible for SSI disability payments if they are born at a low weight relative to their gestational age. Due to these somewhat arbitrary weight thresholds, in our analysis we compare infants, that are otherwise observationally similar but differ in their eligibility for and receipt of benefits. Because low birth weight is not the only criteria through which a child can receive SSI disability payments, and because we are unable to observe if an infant actually receives SSI disability payments, we utilize a fuzzy regression discontinuity (RD) design to estimate the effects of SSI eligibility for infants on future academic outcomes.

Because our analysis makes use of multiple thresholds determined by both gestational age and birth weight (see Table 3.1), we estimate the following equation:

$$Y_i = \beta right_i + \sum_{d=1}^{7} \alpha_d D_{di} + \sum_{d=1}^{7} \gamma_d f_d(birthweight_i) D_{di} + \sum_{d=1}^{7} \alpha_d f_d(birthweight_i) D_{di} right_i + u_i \tag{3.1}$$

where Y_i represents the academic outcome we investigate for individual i : grade repetition and reported learning disability. The indicator variables D_{di} take a value of 1 if the individual is categorized within that threshold determined by their gestational age and birth weight, $right_i$ is an indicator variable for whether the individual's birth weight lies to the right of its relevant threshold (and are thus not eligible for SSI disability payments), and $f_d(birthweight_i)$ is a polynomial in birth weight difference from the threshold. Because SSI disability is determined by both gestational age and birth weight, each infant by definition falls within only one threshold. We use bandwidth choices of 200 grams and 150 grams (Guldi et. al). The parameter β is our parameter of interest and estimates the local average treatment effect of not being eligible for SSI disability payments.

3.4 Validity of RDD

3.4.1 Frequency of Births Around Weight Thresholds

In order for regression discontinuity design to be valid, birth weight must not be precisely controlled. The validity of our design would be threatened if reported birth weight is strategically reported. In Figure 3.1 we investigate this possibility by plotting the number of births by birth weight. Because we make use of multiple birth weight thresholds, Figure 3.1 plots each individuals' birth weight by subtracting off the relevant birth weight cutoff threshold. The x-axis therefore is measured as the distance from the relevant weight cutoff thresholds and centers each birth weight threshold at 0. The first histogram plots birth weights for the entire sample of individuals for whom we observe a birth weight. Much of our analysis will focus on birth weight within 200 grams of the weight threshold cutoff. The second histogram zooms in on the relevant range of birthweights within 300 grams of the threshold cutoff.

Neither histogram shows evidence of strategic reporting of birth weight just below the thresholds. However, as expected due to physician rounding of birth weight, there is substantial heaping of births at round number of ounces (Barreca et al., 2011).

3.4.2 Comparison of Covariates

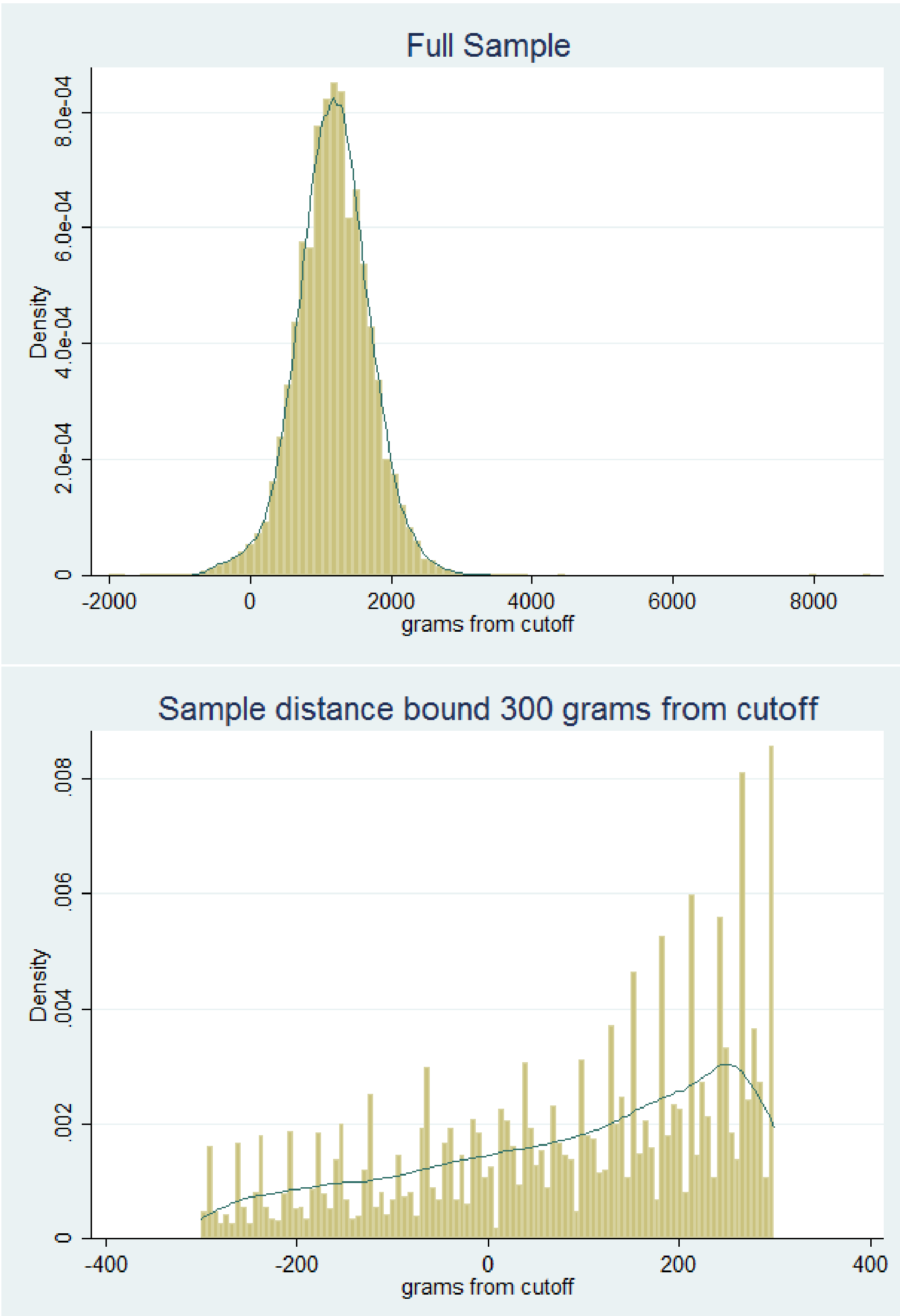
It would be problematic for our empirical strategy if we observed discontinuities in the baseline covariates such as mother's age at birth, mother's education at birth, tobacco use, and number of prenatal visits. If this were the case, it could imply that our results are driven by these covariate differentials instead of SSI disability eligibility. We test for discontinuities in the baseline covariates at the thresholds by plotting these covariates to the left and right of the birth weight thresholds, and by replacing each of the covariates as the dependent variable in our main specification. Table 3.4 reports the RD parameter estimates and Figure 3.2 displays the RD plots. We find no evidence of a discontinuity in our baseline covariates suggesting that infants born just below the SSI disability eligibility threshold are suitable comparisons for infants born just above the SSI disability eligibility threshold. To assure our results capture solely the effects of SSI disability eligibility and not other potential medical interventions, we exclude infants surrounding the 1500 gram birth weight (<=34 gestational weeks) threshold (Almond et al., 2010).

Table 3.4: Balance Check on Baseline Covariates

	SSI Eligibility	
	200g window	*150g window*
Dependent Variables		
Mother's age	-0.319	-0.773
	(0.509)	(0.605)
	2,384	1,676
Mother's education	0.558	0.772
	(0.693)	(0.829)
	2,384	1,676
Male	-0.065	-0.033
	(0.040)	(0.048)
	2,383	1,675
Tobacco	0.023	0.057
	(0.048)	(0.061)
	2,384	1,676
# Prenatal Visits	0.100	0.301
	(0.422)	(0.510)
	2,291	1,607

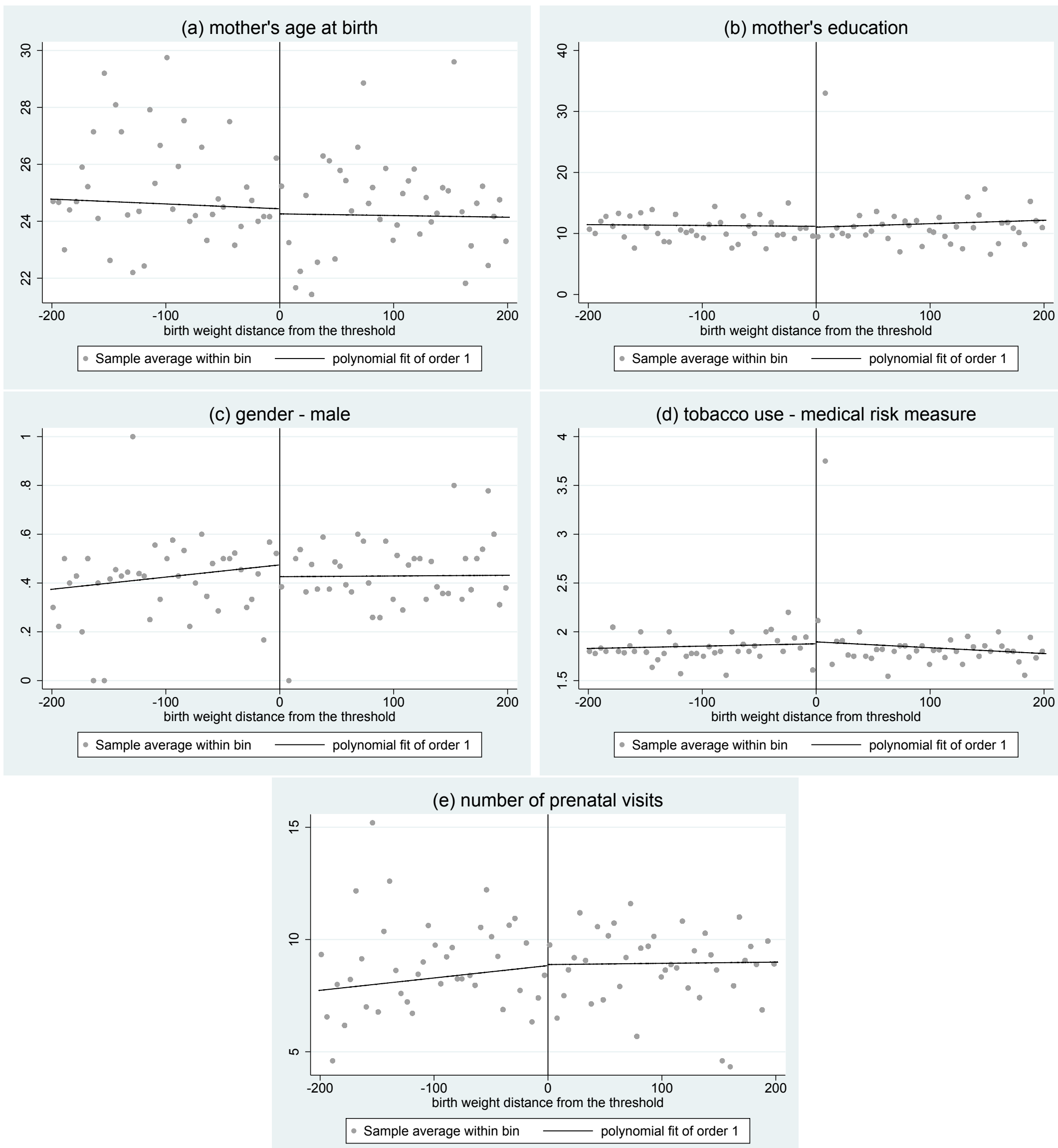
Notes: The coefficient estimates in this table represent the effect of being ineligible for SSI disability payments on baseline covariates. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. The number of observations is reported beneath the standard errors.

Figure 3.1: Birth Weight Thresholds



Notes: The figures plot the frequency of births by birth weight. The x-axis represents the distance from the weight cutoff thresholds.

Figure 3.2: Balance Check on Baseline Covariates



Notes: The figures plot average values for each covariate within the bins to the left and right of the birth weight thresholds.

3.5 Results

We first examine the effects of SSI disability eligibility on the probability of repeating a grade elementary or middle school and the probability that the individual has a registered learning disability in their school. Approximately 18% of the sample we investigate repeats at least one grade within elementary through middle school and nearly 20% of the sample has a registered learning disability in their school. Table 3.5 reports the RD parameter estimates on grade repetition and learning disabilities for 200 gram and 150 gram bandwidths. For each outcome, the first row presents results from the linear flexible models and the second row presents results from the quadratic flexible model.

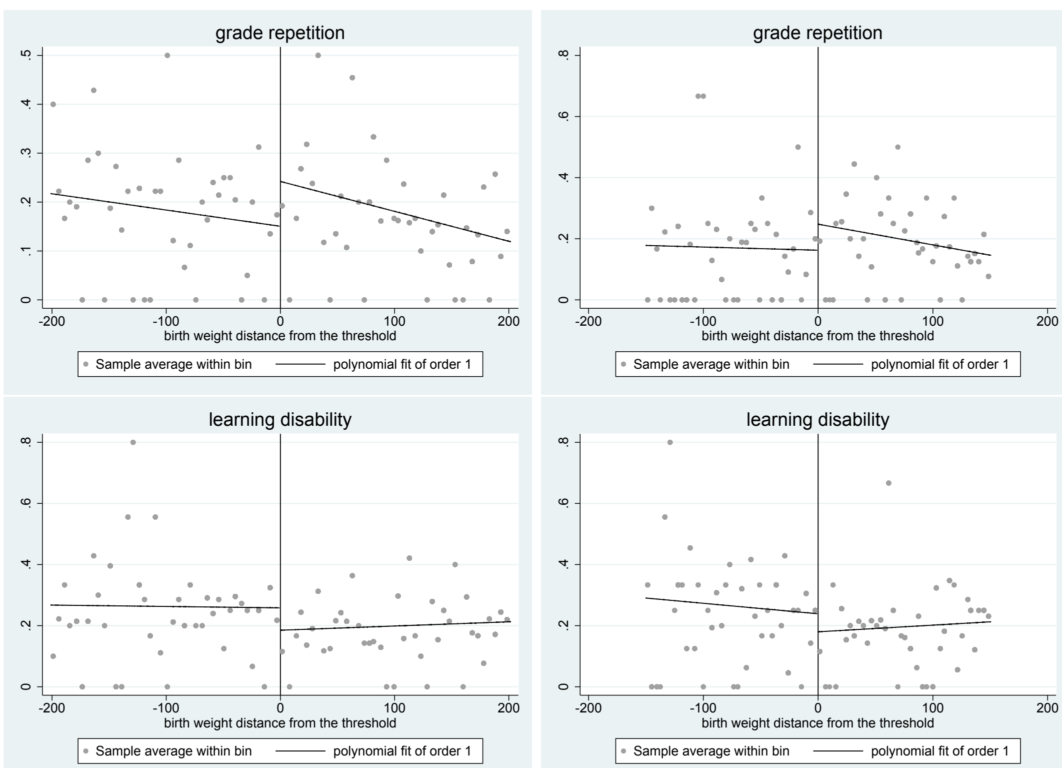
The first column shows that infants who are eligible for SSI disability benefits are 4.5 - 7 percentage points less likely to ever repeat a grade in elementary or middle school. When we narrow the bandwidth to 150 grams around the thresholds, the estimates still suggest that infants eligible for SSI disability benefits are 4.4 - 6.1 percentage points less likely to ever repeat a grade but the estimate is no longer statistically significant, likely due to the sample size reduction. The second column shows that infants who are eligible for SSI disability benefits are 7.2 - 7.6 percentage points more likely to have a registered learning disability in their school. When we narrow the bandwidth to 150 grams around the thresholds, we still find a statistically significant effect that SSI disability eligibility increases the likelihood of registering a learning disability in school by 6.7 percentage points.

Table 3.5: SSI Disability Eligibility Effects on Outcomes

	Grade Repetition		**Learning Disability**	
	200g window	*150g window*	*200g window*	*150g window*
Flexible Linear				
SSI Eligibility	0.070**	0.061	-0.076**	-0.067*
	(0.032)	(0.038)	(0.034)	(0.040)
Flexible Quadratic				
SSI Eligibility	0.045*	0.044	-0.072***	-0.067**
	(0.024)	(0.029)	(0.026)	(0.030)
Mean	0.180	0.183	0.208	0.208
N obs.	2,384	1,676	2,384	1,676

Notes: The coefficient estimates in this table represent the effect of being ineligible for SSI disability payments on academic outcomes. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses.

Figure 3.3: The Effects of SSI Disability on Outcomes



Notes: The figures plot average values for each outcome within the bins to the left and right of the birth weight thresholds.

3.6 Discussion

Low birth weight infants have worse health and academic outcomes in both the short-run and long-run. In this paper, we investigate if SSI disability payments can assist in mitigating the adverse effects of low birth weight.

In this paper, we implement a regression discontinuity design to estimate the effects of SSI eligibility for infants on future academic outcomes. Our results show that individuals eligible for SSI disability are less likely to repeat a grade, but are more likely to have a registered learning disability in school.

Our findings suggest that SSI disability eligibility can have positive effects on future academic performance. Given that SSI eligibility also makes it more likely for a child to be diagnosed with a learning disability, it is plausible that disability payments allow parents to provide better medical care leading to a diagnosis, or perhaps a learning disability diagnosis prolongs disability payments.

Appendices

Appendix A ADHD Medication Effects on Primary and Secondary Students' Academic Achievement

Table 6: Effects of ADHD Medication on English, Math, & Science Test Scores

	Elementary School			Middle School		
	English	**Math**	**Science**	**English**	**Math**	**Science**
Panel A. Female Combined-ADHD:						
Treatment	-0.184**	-0.218***	-0.159*	-0.471***	-0.496***	-0.459***
	(0.085)	(0.082)	(0.082)	(0.075)	(0.072)	(0.080)
Mean	2.737	2.338	2.244	2.371	2.119	2.249
N obs.	10,169	10,233	6,924	8,244	8,243	5,519
R^2	0.206	0.212	0.225	0.228	0.214	0.229
Panel B. Male Combined-ADHD:						
Treatment	0.010	0.051	0.027	-0.100	-0.094	-0.087
	(0.078)	(0.077)	(0.075)	(0.072)	(0.072)	(0.085)
Mean	2.624	2.404	2.318	2.215	2.077	2.232
N obs.	22,421	22,542	15,067	17,284	17,281	11,594
R^2	0.193	0.201	0.215	0.186	0.183	0.193
Panel C. Female PI-ADHD:						
Treatment	-0.192	-0.016	-0.158	-0.158	0.049	0.266
	(0.189)	(0.184)	(0.178)	(0.156)	(0.150)	(0.162)
Mean	2.710	2.309	2.252	2.371	2.116	2.279
N obs.	3,540	3,551	2,405	3,809	3,807	2,541
R^2	0.231	0.215	0.233	0.213	0.207	0.224
Panel D. Male PI-ADHD:						
Treatment	0.241	0.346**	0.300**	-0.060	0.120	-0.182
	(0.149)	(0.147)	(0.148)	(0.148)	(0.144)	(0.155)
Mean	2.623	2.413	2.350	2.240	2.086	2.273
N obs.	6,125	6,157	4,131	6,195	6,190	4,128
R^2	0.191	0.191	0.208	0.196	0.176	0.215

Notes: The coefficient estimates in this table can be interpreted as the effect of ADHD medication within a year of the individual's ADHD diagnosis on the individual's English, math and science test score. All specifications include school controls, birth year, year of diagnosis, and school year controls. We also control for the individual's grade, comorbid psychiatric conditions, if the individual is English proficient, mother's age and education at birth, family income, number of children and adults in the household, and number of patients diagnosed by the individual's diagnosing provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

Table 7: ADHD Treatment Effects on Elementary & Middle School Test Scores: By Gender

	Elementary School				**Middle School**			
	Female		**Male**		**Female**		**Male**	
	OLS	**IV**	**OLS**	**IV**	**OLS**	**IV**	**OLS**	**IV**
Treatment	-0.061***	**-0.047**	-0.001	**0.014**	-0.090***	**-0.180*** **	-0.042***	**-0.036**
	(0.011)	**(0.040)**	(0.007)	**(0.037)**	(0.012)	**(0.034)**	(0.009)	**(0.034)**
Race: Black	-0.203***	-0.201***	-0.196***	-0.195***	-0.190***	-0.199***	-0.192***	-0.192***
	(0.011)	(0.011)	(0.008)	(0.009)	(0.012)	(0.012)	(0.008)	(0.008)
Hispanic	-0.079	-0.077	-0.071*	-0.069	0.082	0.062	-0.060	-0.059
	(0.051)	(0.051)	(0.042)	(0.043)	(0.077)	(0.078)	(0.048)	(0.048)
Other	-0.074***	-0.072***	-0.107***	-0.107***	-0.073***	-0.083***	-0.129***	-0.129***
	(0.026)	(0.026)	(0.015)	(0.015)	(0.026)	(0.027)	(0.018)	(0.018)
Num children in HH	-0.012**	-0.011**	-0.009***	-0.009***	-0.007	-0.008	-0.007**	-0.007**
	(0.005)	(0.005)	(0.003)	(0.003)	(0.006)	(0.006)	(0.003)	(0.003)
Free lunch	-0.024	-0.025	-0.061***	-0.061***	-0.040**	-0.037**	-0.057***	-0.057***
	(0.017)	(0.017)	(0.013)	(0.013)	(0.017)	(0.017)	(0.011)	(0.011)
Mother's Educ: Less than HS	-0.074***	-0.073***	-0.051***	-0.051***	-0.122***	-0.119***	-0.080***	-0.080***
	(0.026)	(0.026)	(0.020)	(0.019)	(0.023)	(0.023)	(0.021)	(0.021)
Some HS	-0.067***	-0.067***	-0.040***	-0.041***	-0.052***	-0.050***	-0.036***	-0.036***
	(0.012)	(0.012)	(0.007)	(0.007)	(0.012)	(0.012)	(0.009)	(0.009)
Some college	0.052***	0.052***	0.055***	0.055***	0.094***	0.096***	0.060***	0.060***
	(0.017)	(0.017)	(0.012)	(0.012)	(0.019)	(0.019)	(0.014)	(0.014)
College degree	0.018	0.018	0.086***	0.087***	0.077**	0.077**	0.071***	0.071***
	(0.026)	(0.025)	(0.018)	(0.018)	(0.031)	(0.031)	(0.019)	(0.019)
Mental condition	-0.051***	-0.051***	-0.055***	-0.055***	-0.020*	-0.018	-0.044***	-0.044***
	(0.011)	(0.011)	(0.007)	(0.007)	(0.012)	(0.012)	(0.008)	(0.008)
Mean	0.406		0.403		0.322		0.290	
N obs.	14,071		29,185		12,340		23,924	
R^2	0.148	0.148	0.151	0.151	0.158	0.150	0.136	0.136

Notes: The coefficient estimates in this table can be interpreted as the effect of ADHD medication within a year of the individual's ADHD diagnosis on the probability of passing both the English and mathematics examinations. All specifications include school controls, birth year, year of diagnosis, and school year controls. We also control for the individual's grade, comorbid psychiatric conditions, if the individual is English proficient, mother's age and education at birth, family income, number of children and adults in the household, and number of patients diagnosed by the individual's diagnosing provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

Table 8: ADHD Treatment Effects on High School Test Scores: By Gender

	Female		**Male**	
	OLS	**IV**	**OLS**	**IV**
Treatment	-0.075***	**-0.170*** **	-0.027	**0.002**
	(0.019)	**(0.053)**	(0.016)	**(0.057)**
Race: Black	-0.171***	-0.184***	-0.195***	-0.192***
	(0.021)	(0.023)	(0.017)	(0.018)
Hispanic	-0.044	-0.020	0.007	0.010
	(0.102)	(0.092)	(0.067)	(0.067)
Other	-0.091*	-0.113**	-0.151***	-0.149***
	(0.048)	(0.048)	(0.034)	(0.033)
Num children in HH	-0.010	-0.015	-0.005	-0.005
	(0.009)	(0.009)	(0.007)	(0.007)
Free lunch	-0.028	-0.019	-0.056**	-0.057***
	(0.028)	(0.028)	(0.022)	(0.022)
Mental condition	-0.108***	-0.110***	-0.076***	-0.074***
	(0.021)	(0.020)	(0.016)	(0.016)
Mean	0.560		0.498	
N obs.	2,693		4,365	
R^2	0.195	0.233	0.179	0.178

Notes: The coefficient estimates in this table can be interpreted as the effect of ADHD medication within a year of the individual's ADHD diagnosis on the probability of passing both the English and mathematics examinations. All specifications include school controls, birth year, year of diagnosis, and school year controls. We also control for the individual's grade, comorbid psychiatric conditions, if the individual is English proficient, mother's age and education at birth, family income, number of children and adults in the household, and number of patients diagnosed by the individual's diagnosing provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

Table 9: ADHD Treatment Effects on Elementary School Test Scores

	Combined Hyper/Inatt				**Predominantly Inattentive**			
	Female		**Male**		**Female**		**Male**	
	OLS	**IV**	**OLS**	**IV**	**OLS**	**IV**	**OLS**	**IV**
Treatment	-0.059***	**-0.046**	0.001	**-0.024**	-0.087***	**-0.164**	-0.008	**0.178****
	(0.013)	**(0.043)**	(0.009)	**(0.039)**	(0.022)	**(0.108)**	(0.018)	**(0.083)**
Race: Black	-0.186***	-0.185***	-0.193***	-0.195***	-0.219***	-0.228***	-0.182***	-0.181***
	(0.014)	(0.014)	(0.010)	(0.011)	(0.025)	(0.029)	(0.017)	(0.017)
Hispanic	-0.050	-0.047	-0.053	-0.056	-0.067	-0.071	-0.046	-0.046
	(0.065)	(0.066)	(0.050)	(0.051)	(0.069)	(0.069)	(0.074)	(0.079)
Other	-0.101***	-0.100***	-0.096***	-0.097***	0.039	0.034	-0.068*	-0.066*
	(0.028)	(0.028)	(0.017)	(0.017)	(0.059)	(0.061)	(0.039)	(0.039)
Num children in HH	-0.009	-0.009	-0.008**	-0.008**	-0.032***	-0.033***	-0.011	-0.009
	(0.007)	(0.007)	(0.004)	(0.004)	(0.010)	(0.010)	(0.009)	(0.009)
Free lunch	-0.003	-0.004	-0.049***	-0.049***	-0.017	-0.017	-0.062**	-0.055**
	(0.020)	(0.020)	(0.014)	(0.014)	(0.032)	(0.032)	(0.026)	(0.027)
Mother's Educ: Less than HS	-0.067**	-0.067**	-0.036	-0.035	-0.095	-0.097	-0.095**	-0.091**
	(0.028)	(0.028)	(0.022)	(0.022)	(0.063)	(0.065)	(0.042)	(0.043)
Some HS	-0.056***	-0.056***	-0.034***	-0.034***	-0.092***	-0.092***	-0.036**	-0.037**
	(0.014)	(0.014)	(0.009)	(0.009)	(0.026)	(0.026)	(0.018)	(0.018)
Some college	0.064***	0.064***	0.055***	0.055***	-0.026	-0.022	0.049**	0.047*
	(0.020)	(0.020)	(0.014)	(0.014)	(0.034)	(0.034)	(0.025)	(0.025)
College degree	0.029	0.029	0.081***	0.079***	-0.002	-0.001	0.138***	0.150***
	(0.028)	(0.028)	(0.020)	(0.020)	(0.056)	(0.055)	(0.038)	(0.038)
Mental condition	-0.056***	-0.057***	-0.050***	-0.050***	-0.030	-0.022	-0.069***	-0.068***
	(0.012)	(0.012)	(0.007)	(0.007)	(0.021)	(0.023)	(0.016)	(0.016)
English proficient	0.089	0.089	0.068	0.069	0.047	0.057	0.075	0.060
	(0.065)	(0.065)	(0.049)	(0.049)	(0.091)	(0.094)	(0.087)	(0.094)
R^2	0.247		0.207		0.377		0.289	

Notes: The coefficient estimates in this table can be interpreted as the effect of ADHD medication within a year of the individual's ADHD diagnosis on the probability of passing both the English and mathematics examinations. All specifications include school controls, birth year, year of diagnosis, and school year controls. We also control for the individual's grade, comorbid psychiatric conditions, if the individual is English proficient, mother's age and education at birth, family income, number of children and adults in the household, and number of patients diagnosed by the individual's diagnosing provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

Table 10: ADHD Treatment Effects on Middle School Test Scores

	Combined Hyper/Inatt				**Predominantly Inattentive**			
	Female		**Male**		**Female**		**Male**	
	OLS	**IV**	**OLS**	**IV**	**OLS**	**IV**	**OLS**	**IV**
Treatment	-0.104***	**-0.202*** **	-0.039***	**-0.060**	-0.087***	**-0.132**	-0.059***	**-0.005**
	(0.015)	**(0.040)**	(0.009)	**(0.037)**	(0.022)	**(0.081)**	(0.021)	**(0.083)**
Race: Black	-0.206***	-0.214***	-0.195***	-0.197***	-0.219***	-0.145***	-0.171***	-0.169***
	(0.014)	(0.015)	(0.009)	(0.010)	(0.025)	(0.021)	(0.018)	(0.018)
Hispanic	0.174**	0.144	-0.050	-0.054	-0.067	0.053	-0.011	-0.008
	(0.087)	(0.088)	(0.065)	(0.065)	(0.069)	(0.135)	(0.077)	(0.076)
Other	-0.093***	-0.104***	-0.126***	-0.127***	0.039	-0.016	-0.133***	-0.134***
	(0.032)	(0.033)	(0.018)	(0.018)	(0.059)	(0.055)	(0.036)	(0.036)
Num children in HH	-0.008	-0.007	-0.009***	-0.009***	-0.032***	0.004	0.007	0.008
	(0.007)	(0.007)	(0.004)	(0.004)	(0.010)	(0.010)	(0.008)	(0.008)
Free Lunch	-0.021	-0.016	-0.058***	-0.058***	-0.017	-0.050	-0.037*	-0.036
	(0.020)	(0.021)	(0.013)	(0.013)	(0.032)	(0.032)	(0.022)	(0.022)
Mother's Educ: Less than HS	-0.128***	-0.124***	-0.064**	-0.064**	-0.095	-0.110**	-0.093***	-0.095***
	(0.026)	(0.026)	(0.025)	(0.025)	(0.063)	(0.049)	(0.036)	(0.035)
Some HS	-0.051***	-0.050***	-0.032***	-0.032***	-0.092***	-0.089***	-0.040**	-0.041**
	(0.014)	(0.014)	(0.010)	(0.010)	(0.026)	(0.024)	(0.019)	(0.019)
Some college	0.089***	0.088***	0.044**	0.044**	-0.026	0.108***	0.078***	0.078***
	(0.023)	(0.024)	(0.017)	(0.017)	(0.034)	(0.031)	(0.024)	(0.024)
College degree	0.072*	0.072*	0.056**	0.056**	-0.002	0.072	0.091**	0.094**
	(0.037)	(0.037)	(0.022)	(0.022)	(0.056)	(0.055)	(0.040)	(0.041)
Mental condition	-0.022*	-0.020	-0.049***	-0.049***	-0.030	0.005	-0.040***	-0.038***
	(0.012)	(0.012)	(0.009)	(0.009)	(0.021)	(0.021)	(0.013)	(0.014)
English proficient	0.450***	0.456***	0.060	0.059	0.047	0.231	0.080	0.073
	(0.084)	(0.086)	(0.069)	(0.069)	(0.091)	(0.146)	(0.093)	(0.095)
R^2	0.230		0.181		0.377		0.211	

Notes: The coefficient estimates in this table can be interpreted as the effect of ADHD medication within a year of the individual's ADHD diagnosis on the probability of passing both the English and mathematics examinations. All specifications include school controls, birth year, year of diagnosis, and school year controls. We also control for the individual's grade, comorbid psychiatric conditions, if the individual is English proficient, mother's age and education at birth, family income, number of children and adults in the household, and number of patients diagnosed by the individual's diagnosing provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

Table 11: ADHD Treatment Effects on High School Test Scores

	Combined Hyper/Inatt				**Predominantly Inattentive**			
	Female		**Male**		**Female**		**Male**	
	OLS	**IV**	**OLS**	**IV**	**OLS**	**IV**	**OLS**	**IV**
Treatment	-0.070***	-0.190***	-0.114***	-0.066	-0.037*	0.019	-0.006	-0.045
	(0.022)	(0.065)	(0.037)	(0.116)	(0.019)	(0.057)	(0.031)	(0.132)
Race: Black	-0.164***	-0.175***	-0.162***	-0.153***	-0.190***	-0.187***	-0.214***	-0.219***
	(0.025)	(0.025)	(0.038)	(0.042)	(0.022)	(0.022)	(0.032)	(0.036)
Hispanic	-0.021	-0.010	0.456***	0.459***	0.002	0.004	0.043	0.035
	(0.104)	(0.107)	(0.149)	(0.145)	(0.071)	(0.071)	(0.100)	(0.105)
Other	-0.116*	-0.120**	-0.071	-0.079	-0.163***	-0.158***	-0.201***	-0.198***
	(0.061)	(0.061)	(0.082)	(0.081)	(0.037)	(0.038)	(0.072)	(0.074)
Num children in HH	-0.009	-0.010	-0.022	-0.021	-0.012	-0.012	0.010	0.010
	(0.012)	(0.012)	(0.018)	(0.018)	(0.009)	(0.008)	(0.015)	(0.015)
Free lunch	-0.025	-0.021	0.010	0.006	-0.047*	-0.049*	-0.089**	-0.089**
	(0.034)	(0.035)	(0.043)	(0.043)	(0.026)	(0.026)	(0.041)	(0.041)
Mental condition	-0.096***	-0.094***	-0.093**	-0.096***	-0.081***	-0.078***	-0.070***	-0.073***
	(0.026)	(0.026)	(0.036)	(0.037)	(0.018)	(0.018)	(0.027)	(0.028)
englishprof	0.031	0.076	0.726***	0.716***	0.092	0.085	0.172	0.178
	(0.131)	(0.136)	(0.208)	(0.201)	(0.116)	(0.116)	(0.136)	(0.140)
R^2	0.312		0.383		0.265		0.288	

Notes: The coefficient estimates in this table can be interpreted as the effect of ADHD medication within a year of the individual's ADHD diagnosis on the probability of passing both the English and mathematics examinations. All specifications include school controls, birth year, year of diagnosis, and school year controls. We also control for the individual's grade, comorbid psychiatric conditions, if the individual is English proficient, mother's age and education at birth, family income, number of children and adults in the household, and number of patients diagnosed by the individual's diagnosing provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

Table 12: IV Probit: Fraction of years treated with medication

	Elementary School	Middle School	High School
Panel A. Female Combined-ADHD:			
Treatment	**-0.073**	**-0.259*** **	**-0.330*** **
	(0.050)	**(0.038)**	**(0.102)**
Mean	0.408	0.320	0.548
N obs.	10,167	8,240	1,685
Panel B. Male Combined-ADHD:			
Treatment	**-0.035**	**-0.088** **	**0.162**
	(0.047)	**(0.045)**	**(0.322)**
Mean	0.402	0.291	0.489
N obs.	22,398	17,267	2,939
Panel C. Female PI-ADHD:			
Treatment	**-0.126**	**-0.143**	**-0.102**
	(0.119)	**(0.111)**	**(0.228)**
Mean	0.393	0.324	0.582
N obs.	3,537	3,805	962
Panel D. Male PI-ADHD:			
Treatment	**0.327*** **	**0.079**	**-0.251**
	(0.093)	**(0.113)**	**(0.245)**
Mean	0.411	0.292	0.517
N obs.	6,122	6,187	1,351

Notes: Treatment is defined as the fraction of Medicaid eligible years the individual takes ADHD medication after their ADHD diagnosis. The outcome variable is defined as the probability of passing both the English and mathematics examinations. All specifications include school controls, birth year, year of diagnosis, and school year controls. We also control for the individual's grade, comorbid psychiatric conditions, if the individual is English proficient, mother's age and education at birth, family income, number of children and adults in the household, and number of patients diagnosed by the individual's diagnosing provider. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

Table 13: Summary Statistics: Individual and Family Characteristics; Undiagnosed Children

	N obs.	Mean	Median	SD	Min	Max
Individual characteristics						
Age 1st in sample	134,075	7.83	8.00	5.02	1	19
Male	134,075	0.45			0	1
Race: White	134,075	0.35			0	1
Black	134,075	0.55			0	1
Hispanic	134,075	0.05			0	1
Family & home environment						
Monthly family net income	134,075	717.06	573.5	660.72	0	6,356
Number of adults	134,075	1.25	1.14	0.58	0	3
Number of children	134,075	2.07	2.00	1.06	0	6
Ever in foster care	134,075	0.04			0	1
Ever had disability	134,075	0.05			0	1
Mother's characteristics						
Age when gave birth	73,923	23.60	22.00	5.62	11	48
Educ: Less than HS	73,923	0.06			0	1
Some HS	73,923	0.33			0	1
HS diploma	73,923	0.42			0	1
Some college	73,923	0.14			0	1
College degree or higher	73,923	0.05			0	1

Notes: The sample includes a random group of SC Medicaid enrollees, who were eligible for Medicaid for at least one year at any age between 3 and 18 years old in 2003-2013 and who did not have an ADHD-related medical history during this time period. Family characteristics are reported on average per patient/eligibility year. Foster care and disability rates are calculated based on the Medicaid enrollment categories. Mother characteristics are reported based on in-state birth certificate information matched to Medicaid records. They are available only for a subsample of the 73,923 patients. Mother's age and educational attainment are recorded at the time of the child's birth. "HS" stands for high school education level.

Table 14: Summary Statistics: Provider/Patients

	Providers	Patients per provider	
Diagnosis year	**Number/year**	**Mean**	**Std**
2003	447	9.667	15.999
2004	560	12.320	24.027
2005	496	11.048	19.484
2006	454	9.991	17.254
2007	476	9.845	17.474
2008	572	9.210	16.618
2009	672	8.330	14.724
2010	787	8.625	12.987
2011	835	8.503	13.581
2012	874	8.572	13.042
Total number of individual doctors	1,953		
Total number of doctor/years	6,371		

Table 15: Evidence of Treatment Shopping

Dependent Variable:	**Switch doctors (0,1)**	
Regressors	**Coeff**	**SE**
Extreme	0.0353***	0.004
Male	0.00113	0.003
Race: Black	0.0001	0.003
Hispanic	0.010	0.016
Other	-0.005	0.007
Mother's Educ: Less than HS	-0.009	0.010
Some HS	0.0004	0.007
HS degree	-0.009	0.007
Some college	-0.0114	0.008
Family income	0.0001	0.002
Num children	-0.005***	0.001
Num adults	-0.003	0.003
Obs	41,721	
R^2	0.024	

Notes: The dependent variable is equal to 1 if an individual switches to a subsequent doctor, 0 otherwise. The variable "extreme" is equal to 1 if the individual's first provider diagnosis all of his patients or none of his patients, 0 otherwise. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively.

Table 16: Summary statistics: Switchers

		DocPTP1 > DocPTP2			DocPTP1 < DocPTP2		
Variable		**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**	**N**
Mother's Educ:	Less than HS	0.042	0.200	1634	0.047	0.211	2485
	Some HS	0.390	0.488	1634	0.395	0.489	2485
	HS degree	0.376	0.484	1634	0.384	0.487	2485
	Some college	0.125	0.331	1634	0.125	0.331	2485
	College degree	0.065	0.246	1634	0.048	0.214	2485
Mother's age		23.697	5.612	1645	23.357	5.410	2503
Family income		0.518	0.756	2261	0.541	0.778	3290
Num children		1.971	1.088	2261	2.028	1.086	3290
Num adults		0.912	0.742	2261	0.929	0.753	3290

Notes: The summary statistics are reported for individuals who switch providers. DocPTP1 represents the individuals' first provider propensity to prescribe, and DocPTP2 represents the individuals' subsequent provider propensity to prescribe.

Appendix B Sex, Drugs, and ADHD: The Effects of ADHD Pharmacological Treatment on Teens' Risky Behaviors

Table 17: Summary Statistics: Individual and Family Characteristics; Undiagnosed Children

	N obs.	**Mean**	**Median**	**SD**	**Min**	**Max**
Individual characteristics						
Age 1st in sample	134,075	7.83	8.00	5.02	1	19
Male	134,075	0.45			0	1
Race: White	134,075	0.35			0	1
Black	134,075	0.55			0	1
Hispanic	134,075	0.05			0	1
Family & home environment						
Monthly family net income	134,075	717.06	573.5	660.72	0	6,356
Number of adults	134,075	1.25	1.14	0.58	0	3
Number of children	134,075	2.07	2.00	1.06	0	6
Ever in foster care	134,075	0.04			0	1
Ever had disability	134,075	0.05			0	1
Mother's characteristics						
Age when gave birth	73,923	23.60	22.00	5.62	11	48
Educ: Less than HS	73,923	0.06			0	1
Some HS	73,923	0.33			0	1
HS diploma	73,923	0.42			0	1
Some college	73,923	0.14			0	1
College degree or higher	73,923	0.05			0	1

Notes: The sample includes a random group of SC Medicaid enrollees, who were eligible for Medicaid for at least one year at any age between 3 and 18 years old in 2003-2013 and who did not have an ADHD-related medical history during this time period. Family characteristics are reported on average per patient/eligibility year. Foster care and disability rates are calculated based on the Medicaid enrollment categories. Mother characteristics are reported based on in-state birth certificate information matched to Medicaid records. They are available only for a subsample of the 73,923 patients. Mother's age and educational attainment are recorded at the time of the child's birth. "HS" stands for high school education level.

Table 18: Summary Statistics: Negative Health Outcomes; Undiagnosed Children

	N obs.	**Mean**	**Median**	**SD**	**Min**	**Max**
Years in sample	134,075	6.72	6.00	3.08	1	11
Outcome: Risky sexual behavior						
1. Teen Pregnancy						
Age at 1^{st} pregnancy	19,750	17.47	18.00	1.42	11	19
Race: White	19,750	0.42			0	1
Black	19,750	0.53			0	1
2. STD						
Age at 1^{st} STD	14,687	16.02	17.00	2.46	11	19
Age at 1^{st} STD (incl. screening)	26,334	16.33	17.00	2.21	11	19
Male	14,687	0.23			0	1
Race: White	14,687	0.38			0	1
Black	14,687	0.56			0	1
Annual cost of STD	14,687	397.61	143.49	1283.26	1	90,461
Annual cost of STD+test	26,334	341.62	169.70	932.95	1	90,461
Outcome: Substance Abuse						
Age at 1^{st} substance abuse	15,073	16.53	17.00	1.92	11	19
Male	15,073	0.47			0	1
Race: White	15,073	0.50			0	1
Black	15,073	0.45			0	1
Annual cost of substance abuse	15,073	1501.46	439.32	3736.11	1	109,293
Outcome: Injuries						
Ever injured	134,075	0.86			0	1
Age at injury	115,526	10.92	11.00	4.41	3	19
Male	115,526	0.48			0	1
Race: White	115,526	0.39			0	1
Black	115,526	0.51			0	1
N of injury claims	134,075	0.36	0.25	0.42	0	11
Annual cost of injuries	115,526	702.09	213.11	3463.53	2	394,516

Notes: The sample includes a random group of SC Medicaid enrollees, who were eligible for Medicaid for at least one year at any age between 3 and 18 years old in 2003-2013 and who did not have an ADHD-related medical history during this time period. Annual costs of negative health outcomes are given in 2013 dollars per patient/year conditional on the occurrence of a negative health outcome. They are based on the Medicaid reimbursement. The out-of-pocket patient costs are nearly zero for our population of interest.

Table 19: Evidence of Treatment Shopping: Predictors of provider switching

Regressors	**Coeff**	**SE**
"Extreme" provider	0.020[a]	0.004
Race: Black	-0.001	0.004
Hispanic	-0.009	0.012
Other	-0.010	0.007
Mother's Educ: Some HS	0.010	0.008
HS degree	-0.001	0.008
Some college	-0.001	0.009
College degree or higher	0.008	0.010
Family net income	0.0003	0.002
Number of children	-0.006[a]	0.002
Number of adults	-0.006[b]	0.003
N obs.	42,693	
R^2	0.016	

Notes: The dependent variable is equal to 1 if an individual switches providers; 0 otherwise. The variable "extreme" provider is equal to 1 if the individual's first provider diagnoses all of his patients or none of his patients; 0 otherwise. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with a, b, and c respectively.

Table 20: Summary statistics: Switchers

	$PP_1 > PP_2$			**$PP_1 < PP_2$**		
Variable	**Mean**	**SD**	**N obs.**	**Mean**	**SD**	**N obs.**
Mother's Educ: Less than HS	0.042	0.200	1,635	0.047	0.211	2,486
Some HS	0.391	0.488	1,635	0.395	0.489	2,486
HS degree	0.376	0.484	1,635	0.385	0.487	2,486
Some college	0.125	0.331	1,635	0.125	0.331	2,486
College degree	0.065	0.246	1,635	0.048	0.214	2,486
Mother's age	23.691	5.614	1,646	23.356	5.409	2,504
Family net income	0.518	0.756	2,262	0.541	0.778	3,291
Number of children	1.971	1.088	2,262	2.028	1.086	3,291
Number of adults	0.912	0.742	2,262	0.929	0.753	3,291

Notes: This table reports summary statistics for individuals who switch providers. PP_1 stands for the first (diagnosing) provider propensity to prescribe, and PP_2 stands for the individuals' subsequent provider propensity to prescribe.

Table 21: Lifetime Effects of ADHD Treatment on Negative Health and Behavioral Outcomes; with Mother Characteristics

	STD		STD+test		Subst. abuse		Pregnancy	
	OLS	**IV**	**OLS**	**IV**	**OLS**	**IV**	**OLS**	**IV**
First stage		0.535^a		0.530^a		0.544^a		0.575^a
		(0.020)		(0.020)		(0.020)		(0.031)
ADHD Treatment	-0.018^b	**-0.024**	-0.022^b	**-0.046**	-0.011	**-0.057**	-0.040^b	**0.004**
	(0.008)	**(0.026)**	(0.010)	**(0.030)**	(0.012)	**(0.041)**	(0.017)	**(0.047)**
Male	-0.120^a	-0.120^a	-0.203^a	-0.202^a	0.045^a	0.048^a	-	-
	(0.009)	(0.009)	(0.011)	(0.011)	(0.010)	(0.010)		
Race: Black	-0.021^b	-0.022^b	0.022^c	0.019	-0.073^a	-0.078^a	-0.026	-0.020
	(0.009)	(0.010)	(0.012)	(0.013)	(0.012)	(0.012)	(0.018)	(0.019)
Hispanic	-0.037	-0.038	-0.046	-0.050	-0.170^a	-0.179^a	-0.191^b	-0.173^b
	(0.035)	(0.035)	(0.044)	(0.044)	(0.051)	(0.051)	(0.080)	(0.081)
Other	-0.031^c	-0.032^c	-0.024	-0.026	-0.098^a	-0.102^a	-0.102^b	-0.099^b
	(0.018)	(0.018)	(0.024)	(0.024)	(0.024)	(0.024)	(0.040)	(0.040)
Number of adults	-0.009	-0.009	-0.019^b	-0.019^b	-0.005	-0.004	-0.005	-0.006
	(0.006)	(0.006)	(0.008)	(0.008)	(0.008)	(0.008)	(0.013)	(0.012)
Number of children	0.002	0.002	0.012^a	0.012^a	0.009	0.009	0.038^a	0.038^a
	(0.003)	(0.003)	(0.004)	(0.004)	(0.006)	(0.006)	(0.008)	(0.008)
Family net income	-0.001]	-0.001	-0.008	-0.008	-0.023^a	-0.023^a	-0.025^b	-0.025^b
	(0.005)	(0.005)	(0.007)	(0.007)	(0.006)	(0.006)	(0.011)	(0.011)
Mean outcome	0.117		0.221		0.237		0.220	
N obs.	6,815		6,694		6,656		2,519	

Notes: The main coefficient estimates (in bold) in this table can be interpreted as the effect of treatment within a year of the individual's ADHD diagnosis on the probability of a negative health outcome during an individual's adolescence. All specifications include individual's county of residence and birth year fixed effects. We also control for the individual's age of the first ADHD diagnosis, Medicaid eligibility timing and length, disability and foster care status, mother's educational attainment, and age when she gave birth. First stage coefficients show the relationship between treatment receipt and physician propensity to prescribe medication. All specifications are estimated on a subsample of relevant birth cohorts of SC Medicaid enrollees and include individuals born between 1987 and 1996. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with a, b, and c respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

Table 22: Lifetime Effects of ADHD Treatment on Outcomes; Children with Mental Health Condition prior to ADHD Diagnosis

	Control				Exclude			
	STD	**STD+test**	**Subst. abuse**	**Pregn.**	**STD**	**STD+test**	**Subst. abuse**	**Pregn.**
First stage	0.511^a	0.507^a	0.511^a	0.540^a	0.488^a	0.486^a	0.490^a	0.528^a
ADHD Treatment	**-0.036**^{c}	**-0.059**^{b}	**-0.068**^{c}	**-0.013**	**-0.034**	**-0.079**^{b}	**-0.011**	**-0.080**
	(0.019)	**(0.023)**	**(0.036)**	**(0.038)**	**(0.025)**	**(0.033)**	**(0.040)**	**(0.052)**
Male	-0.120^a	-0.205^a	0.041^a	-	-0.120^a	-0.198^a	0.042^a	-
	(0.007)	(0.008)	(0.008)		(0.009)	(0.010)	(0.011)	
Race: Black	-0.012^c	0.011	-0.081^a	-0.020	-0.020^b	0.009	-0.066^a	-0.037^c
	(0.007)	(0.009)	(0.010)	(0.014)	(0.008)	(0.011)	(0.012)	(0.019)
Hispanic	-0.044^b	-0.036	-0.115^a	-0.071^c	-0.040	-0.034	-0.077^b	-0.063
	(0.021)	(0.025)	(0.025)	(0.036)	(0.030)	(0.033)	(0.031)	(0.048)
Other	-0.019^c	-0.032^b	-0.096^a	-0.069^a	0.012	-0.013	-0.082^a	-0.031
	(0.011)	(0.014)	(0.017)	(0.024)	(0.020)	(0.025)	(0.025)	(0.042)
Number of adults	-0.007^c	-0.016^a	-0.015^a	-0.012	0.001	-0.011^c	-0.011^c	-0.006
	(0.003)	(0.005)	(0.006)	(0.008)	(0.005)	(0.006)	(0.007)	(0.012)
Number of children	0.007^a	0.011^a	0.010^a	0.035^a	0.005	0.014^a	0.006	0.024^a
	(0.003)	(0.003)	(0.003)	(0.005)	(0.004)	(0.005)	(0.004)	(0.007)
Family net income	-0.002	-0.009	-0.027^a	-0.023^a	-0.004	-0.009	-0.024^a	-0.010
	(0.004)	(0.005)	(0.005)	(0.007)	(0.005)	(0.006)	(0.006)	(0.010)
Mental health condition	-0.001	-0.004	0.017^b	0.034^a	-	-	-	-
	(0.006)	(0.008)	(0.008)	(0.012)				
Mean outcome	0.117	0.212	0.236	0.265	0.115	0.207	0.224	0.254
N obs.	14,248	13,896	13,668	5,339	7,509	7,408	7,472	2,737

Notes: The main coefficient estimates (in bold) in this table can be interpreted as the effect of treatment within a year of the individual's ADHD diagnosis on the probability of a negative health outcome during an individual's adolescence. All specifications include individual county of residence and birth year fixed effects. We also control for the individual's age and net family income at first ADHD diagnosis, length of Medicaid eligibility, disability, comorbid conditions, and foster care status. First stage coefficients show the relationship between treatment receipt and physician propensity to prescribe medication. All specifications are estimated on a subsample of relevant birth cohorts of SC Medicaid enrollees and include individuals born between 1987 and 1996. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with a, b, and c respectively. Standard errors are in parentheses. They are clustered by individual's provider who diagnosed them with ADHD.

Appendix C Social Security Supplemental Security Income (SSI) Disability Benefits on Future Educational Achievement

Table 23: Robustness: SSI Disability Eligibility on Outcomes Excluding 1500g Threshold

	Grade Repetition		Learning Disability	
	200g window	**150g window**	**200g window**	**150g window**
Flexible Linear				
SSI Eligibility	0.065**	0.049	-0.084**	-0.079*
	(0.033)	(0.039)	(0.035)	(0.041)
Flexible Quadratic				
SSI Eligibility	0.043*	0.037	-0.077***	-0.074**
	(0.025)	(0.029)	(0.026)	(0.030)
Mean	0.179	0.182	0.208	0.207
N obs.	2257	1583	2257	1583

Notes: The coefficient estimates in this table represent the effect of being ineligible for SSI disability payments on academic outcomes. Coefficient estimates that are significant at 1%, 5%, and 10% level are denoted with ***, **, and * respectively. Standard errors are in parentheses.

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